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[Title of the Invention] Image copying device

[Claims]

[Claim 1]

An image copying device that comprises a reading means for reading in an image formed on one surface of a document, a storage means for storing image data that is read in by the reading means and an image forming means for forming an image on a recording medium based on the image data stored in the storage means, the image copying device further comprising;

a reading control means for providing control such that, when a plurality of documents having images formed on both sides thereof are to be read by the reading means, images formed on one surfaces of the documents are read in sequentially and are stored sequentially in the storage means, and then, after the reading in of the one surfaces of the documents is completed, images on the other surfaces of the documents are read in sequentially and are stored sequentially in the storage means; and

image forming control means for reading out, from the storage means, image data for the one surfaces of the documents and the corresponding image data of the other surfaces of the documents, for controlling the image forming means for forming images sequentially on the recording medium based on the image data, and for causing

the start of the forming of images on the recording medium by the image forming means before the reading in of all of the other surfaces of the documents by the reading means has been completed.

[Claim 2]

The image copying device as claimed in claim 1, wherein the image forming control means reads out and sets, into a pair of image data, image data for one surface of each document and image data for the other surface of the subject document, which is stored in the storage means, and forms an image based on the image data for the one surface of the document on one surface of a recording medium and an image based on the image data for the other surface of the subject document on another surface of the recording medium.

[Claim 3]

The image copying device as claimed in claim 1 or 2, wherein the image forming control means performs control in such a manner that, after the images on the one surfaces of all the documents has been read in by the reading means, the reading of the other surfaces and the forming of images onto the recording medium by the image forming means are executed in parallel with each other.

[Claim 4]

The image copying device as claimed in any of claims 1 to 3, wherein the image forming control means performs control in such a manner that the forming of images onto

the recording medium by the image forming means is started after the reading of the other surfaces of the documents has started and when image data for the other surface of at least one document has been stored in the storage means.

[Claim 5]

The image copying device as claimed in any of claims 1 to 3, wherein the image forming control means offsets, based on an estimated value of the time required until the reading in of the other surfaces of all of the documents by the reading means has ended and an estimated value of the time required until image forming based on image data for both surfaces of all of the documents by the image forming means has ended, the start time of image forming by the image forming means with respect to the start time of the reading of the other surfaces of the documents by the reading means in such a manner that the end time of the reading of the other surfaces of all of the documents is earlier than the end time of image forming based on the image data for all of the documents.

[Claim 6]

The image copying device as claimed in any of claims 1 to 3, wherein image forming based on image data for the other surface of a document by the image forming means is performed before image forming based on the one surface of the subject document; and

the image forming control means offsets, based on an

estimated value of the time required until the reading in of the other surface of the document by the reading means has ended and an estimated value of the time required until the image forming based on image data for the other surface of the document has ended, the start time of image forming of the other surface of the document by the image forming means with respect to the start time of the reading of the other surface of the subject document, in such a manner that the end time of the reading of the other surface of the document is earlier than the end time of image forming based on the image data of the other surface of the document.

[Claim 7]

The image copying device as claimed in any of claims 1 to 3, wherein image forming based on image data for the one surface of a document by the image forming means is performed before image forming based on the other surface of the subject document; and

the image forming control means offsets, based on an estimated value of the time required until the reading in of the other surface of the document by the reading means has ended and an estimated value of the time required until the image forming based on image data for both surfaces of the document has ended, the start time of image forming by the image forming means with respect to the start time of the reading of the other surface of the document, in such a

manner that the end time of the reading of the other surface of the document is earlier than the end time of image forming based on the image data of both surfaces of the document.

[Claim 8]

The image copying device as claimed in any of claims 1 to 7, wherein the reading in of the other surface of a document and the image forming based on the image data for the other surface of the document are performed in parallel; and

the image forming control means temporally stops the operation of the image forming means when image data for the other surface of the document that is to be formed by the image forming means becomes insufficient before the reading in of the other surface of the document by the reading means has completed.

[Claim 9]

The image copying device as claimed in any of claims 1 to 7, wherein the reading in of the other surface of a document and the image forming based on the image data for the other surface of the document are performed in parallel; and

the reading control means controls the operation of the reading means in such a manner that the reading in of the other surface of a document next to the subject document starts after the image forming of the other

surface of the subject document by the image forming means has ended.

[Claim 10]

The image copying device as claimed in any of claims 1 to 9, wherein when the one surfaces of the documents are read in by the reading means in the arrangement sequence of the documents and data for all the pages of said documents is stored by the storage means, the other surfaces are read in by the reading means in the reverse arrangement sequence of the documents and are stored in the storage means;

when the one surfaces of the documents are read in by the reading means in the reverse arrangement sequence of the documents and data for all the pages of the documents is stored by the storage means, the other surfaces are read in by the reading means in the arrangement sequence of the documents and are stored in the storage means; and

the image forming control means performs control in such a manner that image data for the one surfaces of the documents that is stored in the storage means and image data for the other surfaces of the documents that is stored in the storage means is read out alternately in page units and images are formed by the image forming means, as well as control in such a manner that image data for the one surface of each page is read out after image data for pages that was read in after the subject page was

read in is read out.

[Claim 11]

The image copying device as claimed in any of claims 1 to 10, wherein the image data stored in the storage means is deleted after the image forming for the image data has been completed by the image forming means.

[Claim 12]

The image copying device as claimed in any of claims 1 to 11, wherein the storage means is provided with:

a first storage area that stores image data for one surfaces of the documents; and

a second storage area that stores image data for the other surfaces of the documents, the first and second storage areas being independent from each other,

wherein image data for the other surface of one document that has been newly read in by the reading means is stored in the second storage area by being overwritten onto image data which has been already stored in the second storage area and for which image forming by the image forming means has ended.

[Claim 13]

The image copying device as claimed in claim 12, wherein the image data is stored in the second storage area in the unit of one page, and image data for the other surface of one document that has been stored in the second storage area is overwritten by image data for the other

surface of a next document that is read in by the reading means next to the subject document.

[Claim 14]

The image copying device as claimed in claim 12 or 13, wherein image data for the other surface of each document is prohibited from being stored in the first storage area and image data for the one surface of each document is prohibited from being stored in the second storage area.

[Claim 15]

The image copying device as claimed in any of claims 12 to 14, wherein the second storage area is set to have a capacity for storing image data that is less than that of the first storage area.

[Claim 16]

The image copying device as claimed in any of claims 12 to 15, further comprising a verification means for checking, upon receipt of a copy instruction, available capacities of the first storage area and the second storage area,

wherein the reading by the reading means is prohibited when the confirmatory result is less than a predetermined amount.

[Claim 17]

The image copying device as claimed in claim 16, wherein the reading by the reading means is started when the verification means has checked that the available

capacity in each of the first storage area and the second storage area is larger than the capacity of image data to be read from at least one document.

[Claim 18]

The image copying device as claimed in any of claims 12 to 17, further comprising a compression means for compressing the image data before the image data is stored in either one of the first storage area and the second storage area.

[Claim 19]

The image copying device as claimed in any of claims 1 to 18, wherein the image forming means is provided with a double-sided print means that is capable of forming images on both sides of a recording medium.

[Detailed Description of the Invention]

[0001]

[Technical Field of the Invention]

The present invention relates to an image copying device that reads in images formed on both sides of a plurality of original documents, links image data for the read-in front surface to image data for the read-in rear surface for each document, then forms images on a recording medium, based on that data.

[0002]

[Prior Art]

An image copying device in the prior art is provided with an automatic document feeder (ADF) for supplying documents to an image reading device such as a charge-coupled device (CCD) or contact image sensor (CIS), to implement the reading in of a plurality of documents sequentially. It then implements the copying (duplication) of images based on the thus-read documents, by forming them on a recording medium by an image forming device such as an inkjet type of recording device or a laser type of recording device.

[0003]

Since the ADF is not generally provided with a document-reversing mechanism, it is necessary for the operator to turn over the pages when copying documents with images formed on both surfaces thereof in such an image

copying device. If there is a plurality of documents with images formed on both sides thereof, the images on one surface of each of the documents sequentially supplied by the ADF (the surfaces of the documents that are read in first, such as the front surfaces) are read in first by a CCD sensor or the like. After that, the images on the other sides of the documents (the surfaces of the documents that are read in after, such as the rear surfaces) are read in the same manner, and images are formed on the basis thereof. The combined reading in of the images on the front surfaces of the documents then the images on the rear surfaces thereof in this manner reduces the work of re-inserting the documents, making it more convenient for the operator, in comparison with a method in which the two surfaces of each document are read in.

[0004]

As disclosed in Patent Reference 1, by way of example, the image data for the front surfaces and the image data for the rear surfaces of all the read-in documents are each stored in an storage device such as RAM, during which time the image data for the front surface of each document is linked to the image data for the rear surface thereof. The forming of these images onto a recording medium is based on the image data that is linked in this manner.

[Reference Document 1]

Japanese Patent Laid-Open No. 7-131601

[0005]

[Problems to be solved by the Invention]

However, in the invention of Reference Document 1, the forming of the images starts after all the image data for the front and rear surfaces of the documents has been read in before the image forming, so that the entire process of copying documents takes a long time from start to finish, which is a burden on the operator. Because the image data for the front and rear surfaces of all the documents is stored in the RAM, the RAM requires a large storage capacity.

[0006]

In view of the above-described drawbacks, it is an objective of the present invention to provide an improved image copying device that has a simple configuration but that can highly efficiently copy documents that have images formed on both sides thereof.

[0007]

[Means for Solving the Problems]

To attain the above object, an image copying device in claim 1 includes: a reading means for reading in an image formed on one surface of a document; a storage means for storing image data that is read in by the reading means; an image forming means for forming an image on a recording medium based on the image data stored in the storage means; a reading control means for providing

control such that, when a plurality of documents having images formed on both sides thereof are to be read by the reading means, images formed on one surfaces of the documents are read in sequentially and are stored sequentially in the storage means, and then, after the reading in of the one surfaces of the documents is completed, images on the other surfaces of the documents are read in sequentially and are stored sequentially in the storage means; and image forming control means for reading out, from the storage means, image data for the one surfaces of the documents and the corresponding image data of the other surfaces of the documents, that controls the image forming means to form images sequentially on the recording medium based on the image data, and that causes the start of the forming of images on the recording medium by the image forming means before the reading in of all of the other surfaces of the documents by the reading means has been completed.

[0008]

In addition to the configuration of the invention of claim 1, the image copying device in claim 2 is characterized in that the image forming control means reads out and sets, into a pair of image data, image data for one surface of each document and image data for the other surface of the subject document, which is stored in the storage means, and forms an image based on the image data

for the one surface of the document on one surface of a recording medium and an image based on the image data for the other surface of the subject document on another surface of the recording medium.

[0009]

In addition to the configuration of the invention of claim 1 or 2, the image copying device in claim 3 is characterized in that the image forming control means performs control in such a manner that, after the images on the one surfaces of all the documents has been read in by the reading means, the reading of the other surfaces and the forming of images onto the recording medium by the image forming means are executed in parallel with each other.

[0010]

In addition to the configuration of the invention of claims 1 through 3, the image copying device in claim 4 is characterized in that the image forming control means performs control in such a manner that the forming of images onto the recording medium by the image forming means is started after the reading of the other surfaces of the documents has started and when image data for the other surface of at least one document has been stored in the storage means.

[0011]

In addition to the configuration of the invention of

claims 1 through 3, the image copying device in claim 5 is characterized in that the image forming control means offsets, based on an estimated value of the time required until the reading in of the other surfaces of all of the documents by the reading means has ended and an estimated value of the time required until image forming based on image data for both surfaces of all of the documents by the image forming means has ended, the start time of image forming by the image forming means with respect to the start time of the reading of the other surfaces of the documents by the reading means in such a manner that the end time of the reading of the other surfaces of all of the documents is earlier than the end time of image forming based on the image data for all of the documents.

[0012]

In addition to the configuration of the invention of claims 1 through 3, the image copying device in claim 6 is characterized in that when image forming based on image data for the other surface of a document by the image forming means is performed before image forming based on the one surface of the subject document, the image forming control means offsets, based on an estimated value of the time required until the reading in of the other surface of the document by the reading means has ended and an estimated value of the time required until the image forming based on image data for the other surface of the

document has ended, the start time of image forming of the other surface of the document by the image forming means with respect to the start time of the reading of the other surface of the subject document, in such a manner that the end time of the reading of the other surface of the document is earlier than the end time of image forming based on the image data of the other surface of the document.

[0013]

In addition to the configuration of the invention of claims 1 through 3, the image copying device in claim 7 is characterized in that when image forming based on image data for the one surface of a document by the image forming means is performed before image forming based on the other surface of the subject document, the image forming control means offsets, based on an estimated value of the time required until the reading in of the other surface of the document by the reading means has ended and an estimated value of the time required until the image forming based on image data for both surfaces of the document has ended, the start time of image forming by the image forming means with respect to the start time of the reading of the both surfaces of the document, in such a manner that the end time of the reading of the other surface of the document is earlier than the end time of image forming based on the image data of other surface of the document.

[0014]

In addition to the configuration of the invention of claims 1 through 7, the image copying device in claim 8 is characterized in that when the reading in of the other surface of a document and the image forming based on the image data for the other surface of the document are performed in parallel, the image forming control means temporally stops the operation of the image forming means when image data for the other surface of the document that is to be formed by the image forming means becomes insufficient before the reading in of the other surface of the document by the reading means has completed.

[0015]

In addition to the configuration of the invention of claims 1 through 7, the image copying device in claim 9 is characterized in that when the reading in of the other surface of a document and the image forming based on the image data for the other surface of the document are performed in parallel, the reading control means controls the operation of the reading means in such a manner that the reading in of the other surface of a document next to the subject document starts after the image forming of the other surface of the subject document by the image forming means has ended.

[0016]

In addition to the configuration of the invention of

claims 1 through 9, the image copying device in claim 10 is characterized in that when the one surfaces of the documents are read in by the reading means in the arrangement sequence of the documents and data for all the pages of said documents is stored by the storage means, the other surfaces are read in by the reading means in the reverse arrangement sequence of the documents and are stored in the storage means, when the one surfaces of the documents are read in by the reading means in the reverse arrangement sequence of the documents and data for all the pages of the documents is stored by the storage means, the other surfaces are read in by the reading means in the arrangement sequence of the documents and are stored in the storage means and the image forming control means performs control in such a manner that image data for the one surfaces of the documents that is stored in the storage means and image data for the other surfaces of the documents that is stored in the storage means is read out alternately in page units and images are formed by the image forming means, as well as control in such a manner that image data for the one surface of each page is read out after image data for pages that was read in after the subject page was read in is read out.

[0017]

In addition to the configuration of the invention of claims 1 through 10, the image copying device in claim 11

is characterized in that the image data stored in the storage means is deleted after the image forming for the image data has been completed by the image forming means.

[0018]

In addition to the configuration of the invention of claims 1 through 11, the image copying device in claim 12 is characterized in that the storage means is provided with a first storage area that stores image data for one surfaces of the documents and a second storage area that stores image data for the other surfaces of the documents, the first and second storage areas being independent from each other, and image data for the other surface of one document that has been newly read in by the reading means is stored in the second storage area by being overwritten onto image data which has been already stored in the second storage area and for which image forming by the image forming means has ended.

[0019]

In addition to the configuration of the invention of claim 12, the image copying device in claim 13 is characterized in that the image data is stored in the second storage area in the unit of one page, and image data for the other surface of one document that has been stored in the second storage area is overwritten by image data for the other surface of a next document that is read in by the reading means next to the subject document.

[0020]

In addition to the configuration of the invention of claims 12 or 13, the image copying device in claim 14 is characterized in that image data for the other surface of each document is prohibited from being stored in the first storage area and image data for the one surface of each document is prohibited from being stored in the second storage area.

[0021]

In addition to the configuration of the invention of claims 12 through 14, the image copying device in claim 15 is characterized in that the second storage area is set to have a capacity for storing image data that is less than that of the first storage area.

[0022]

The image copying device in claim 16, as claimed in any of claims 12 to 15, further comprises a verification means for checking, upon receipt of a copy instruction, available capacities of the first storage area and the second storage area, and is characterized in that wherein the reading by the reading means is prohibited when the confirmatory result is less than a predetermined amount.

[0023]

In addition to the configuration of the invention of claim 16, the image copying device in claim 17 is characterized in that the reading by the reading means is

started when the verification means has checked that the available capacity in each of the first storage area and the second storage area is larger than the capacity of image data to be read from at least one document.

[0024]

In addition to the configuration of the invention of claims 12 through 17, the image copying device in claim 18 is characterized in that the image copying device further comprises a compression means for compressing the image data before the image data is stored in either one of the first storage area and the second storage area.

[0025]

In addition to the configuration of the invention of claims 1 through 18, the image copying device in claim 19 is characterized in that the image forming means is provided with a double-sided print means that is capable of forming images on both sides of a recording medium.

[0026]

[Embodiments]

A copy machine according to an embodiment of the present invention will be described while referring to the accompanying drawings. First, the overall configuration of the copy machine 100 of the present embodiment will be described with reference to Figs. 1 to 3. Note that in the description of the present embodiment, the forward direction, the left-hand direction, the right-hand

direction, the rearward direction, the upward direction, and the downward direction of the copy machine 100 are assumed to be a -Z direction, a -X direction, a +X direction, a +Z direction, a +Y direction, and a -Y direction, respectively.

[0027]

As shown in Fig. 1, the copy machine 100 includes an image reading portion 200 that reads in documents, an image forming portion 300 that forms images on a recording medium based on the read-in image data of the documents and an operating portion 400 used for operating the copy machine 100. The image forming portion 300 has a substantially cubical form, on which is mounted the image reading portion 200 that has a substantially parallelepiped form whose length is greater than that of the image forming portion 300. The image reading portion 200 is oriented with a longitudinal axis extending in the left-and-right direction (X-axis direction) of the copy machine 100. The operating portion 400 protrudes from the image reading portion 200 further outward than the front surface side (the -Z direction) of the copy machine 100.

[0028]

Within the image reading portion 200, at the left edge thereof, an ADF (automatic document feeder) 210 is provided to extend across the image reading portion 200 along its widthwise direction (the Z-axis direction).

According to the ADF 210, documents that are stacked on top of a supply tray 220 are fed, are read by a CCD image sensor 211 (Fig. 2), which is provided in the image reading portion 200, and are discharged onto a discharge tray 230. The supply tray 220 protrudes in a plate shape so as to form an inclined surface which extends diagonally upwardly to the right from the ADF 210. The documents can be held in a stack on the supply tray 220. A document detection sensor 221 (Fig. 2) is provided in the supply tray 220. The document detection sensor 221 employs a photosensor or the like, and detects whether or not documents are placed on the tray 220. The discharge tray 230 is provided below the supply tray 220. The discharge tray 230 extends substantially horizontally to the right from the ADF 210 at a region between the two edges of the image reading portion 200 in the left-and-right direction (the X-axis direction). The discharge tray 230 holds the documents discharged from the ADF 210 in a stack. Note that the image reading portion 200 is equivalent to a "reading means" in accordance with the present invention.

[0029]

The discharge tray 230 can be opened and closed. More specifically, the discharge tray 230 is capable of pivoting about an axis (not shown), which is provided on the rear-surface side of the copy machine 100 and which extends in the X-axial direction. When the discharge tray

230 is opened, the front side of the discharge tray 230 moves upwardly together with the ADF 210 and the supply tray 220, as a result of which a glass plate 212 is exposed. The glass plate 212 (Fig. 2) is provided below the discharge tray 230. The glass plate 212 is made of a transparent glass plate, and is for mounting thereon a document to be read in according to a so-called flat-bed reading method.

[0030]

As shown in Fig. 2, a feed path 213 is provided in the interior of the image reading portion 200 to extend in an arc shape. The feed path 213 is for guiding the documents. A document mounted on top of the supply tray 220 is guided along the fed path 213 to confront the CCD image sensor 211 via the glass plate 212 before reaching the discharge tray 230. A supply roller 214 is provided at one end of the feed path 213 in the document-feed direction. The supply roller 214 is for guiding the stacked document into the feed path 213. A pressure roller 215 is provided at a position along the feed path 213 and faces the CCD image sensor 211. The pressure roller 215 is for pressing each document against the glass plate 212 when the document passes by the CCD image sensor 211. A discharge roller 216 is provided at the other end of the feed path 213 in the document-feed direction. The discharge roller 216 is for discharging the document onto the discharge tray 230. A

passage detection sensor 222 is provided at a position along the feed path 213 and close to the supply roller 214. The passage detection sensor 222 is for detecting whether or not a document has passed.

[0031]

The speed, at which documents are fed by the ADF 210, is previously determined through an experiment. It is possible to estimate the length of each document in the direction of feed by measuring the period of time from the timing when detection of the subject document starts (the timing at which the leading edge of the document is detected by the passage detection sensor 222) to the timing when the detection of the document ends (the timing at which the trailing edge of the document is detected by the passage detection sensor 222). In addition, if the detection of the document does not end even after a predetermined period of time has elapsed, it is known that a paper-jam has occurred.

[0032]

The CCD image sensor 211 is a linear sensor that extends in a direction (Z-axis direction in Fig. 1), which is orthogonal to the feed direction (X-axis direction) of the documents. The CCD image sensor 211 has a plurality of photodiodes (not shown) that are arranged in the extension direction (Z-axis direction). The photodiodes receive light that is reflected off the document when a light from

a light source (not shown) has been irradiated on the document, and then convert the strength (brightness) of the light reflected at each pixel of the document into an electrical signal. An A/D converter 550 (Fig. 4) in the image reading portion 200 converts the signal into digital data, thereby reading in the image formed on the document as image data.

[0033]

The reading of a document can be executed by placing the document on top of the glass plate 212 or by using the ADF 210. In the former, the CCD image sensor 211 is moved in the right-and-left (lateral) direction (X-axis direction) along the surface of the glass plate 212, during which time the document placed on the glass plate 212 is read in one line at a time. In the latter, the CCD image sensor 211 is moved to the left edge of the glass plate 212, where the CCD image sensor 211 faces the pressure roller 215 through the glass plate 212, and is fixed at the position. The document is fed through by the ADF 210, and is read in one line at a time.

[0034]

As shown in Fig. 1, a paper supply cassette 310 is provided in the bottom portion of the image forming portion 300 in such a manner that the paper supply cassette 310 can be inserted into and removed from the front side of the copy machine 100. The paper supply cassette 310 holds

therein a stack of paper as a recording medium. A paper discharge tray 320 is provided in an upper portion of the image forming portion 300, and is for holding a stack of paper that has been discharged after being printed images. [0035]

As shown in Fig. 3, at substantially the center of the image forming portion 300 is provided a print portion 330. The print portion 330 forms a toner image by a known laser recording method on a paper that is being fed from the front-surface side (-Z side) of the copy machine 100 to the rear-surface side (+Z side) of the copy machine 100. An S-shaped feed path is provided so that the paper is guided from the paper supply cassette 310 in the bottom portion, through the print portion 330, and into the paper discharge tray 320 in the upper portion. The S-shaped transfer path is made from a feed path 340, a feed path 345, and a feed path 350. A paper supply roller 341 is provided above the front-surface side portion of the paper supply cassette 310. The feed path 340 is in the shape of a half-arc. The feed path 340 receives a sheet of paper that is sent toward the front-surface side of the copy machine 100 by the paper supply roller 341, and causes the sheet of paper to make a U-turn. The feed path 345 continues on from the feed path 340 to guide the paper into the print portion 330. The feed path 350 is in the shape of another half-arc. The feed path 350 causes the paper that has had

an image formed thereon to make another U-turn, and guides the paper onto the paper discharge tray 320. Paper discharge rollers 361 are provided at the trailing end of the feed path 350 in the direction in which the paper travels, and for discharging the paper onto the paper discharge tray 320.

[0036]

A laser beam generator 331, a photosensitive drum 332, a transfer roller 333, and a fixing unit 334 are provided in the print portion 330. The laser beam generator 331 generates a laser beam based on image data, and scans the laser beam over the surface of the photosensitive drum 332. The photosensitive drum 332 rotates while the surface thereof is being charged uniformly by a charger (not shown). The potential at portions that are irradiated by the laser beam scanned by the laser beam generator 331 (bright portions) decreases with respect to the non-irradiated portions (dark portions). As a result, an electrostatic latent image is formed on the surface of the photosensitive drum 332 according to the thus created potential difference. A toner image is formed on the surface of the photosensitive drum 332 when toner supplied by a developer (not shown) is selectively attracted electrostatically to the bright portions on the surface of the photosensitive drum 332. The transfer roller 333 faces the surface of the photosensitive drum 332 with the paper being sandwiched

between the transfer roller 333 and the photosenstivie drum 332. The toner image is electrically transferred onto the upper surface of the paper when the paper passes through between the transfer roller 333 and the photosenstivie drum 332. The fixing unit 334 applies heat and pressure to the paper to which the toner image has been transferred, to fix the toner on to the paper. Note that the image forming portion 300 is equivalent to an "image forming means" in accordance with the present invention.

[0037]

The image forming portion 300 is further provided with a double-sided print mechanism for printing on both sides of the paper. A feed path 360 is provided for turning the printed sheet of paper over and guiding the sheet of paper into the print portion 330 in such a manner that the sheet of paper which has been printed on one side can be printed on the other side as well. The feed path 360 is provided on the outer side of the half-arc-shaped feed path 350. The paper is fed along the feed path 360 downward from the paper discharge rollers 361, past a position between the print portion 330 and the paper supply cassette 310, and is guided finally to the feed path 345. Paper that has been printed on one side is temporarily discharged on the paper discharge tray 320, at which time the trailing edge of the paper in the feed direction is separated from the feed path 350, but the paper discharge

rollers 361 continue holding the paper therebetween. The rotation of the paper delivery rollers 361 is then reversed, as a result of which the paper is fed in the opposite direction. At this time, the leading edge of the paper, which has been the trailing edge of the paper while the paper has been transferred along the feed path 350, is guided into the feed path 360. Feed rollers 362, 363, and 364 are provided along the feed path 360. When the paper arrives at the feed path 345 after being transported by the feed rollers 362, 363, and 364, front and back surfaces of the paper are reversed. Note that the double-sided print mechanism configured of the feed path 360 and the feed rollers 362 to 364 is equivalent to a "double-sided print means" in accordance with the present invention.

[0038]

As shown in Fig. 1, the operating portion 400 is an input/output portion in the form of a panel, and extends in the right-and-left (lateral) direction (X-axis direction). The operating portion 400 is provided with a plurality of switches and buttons that the operator uses for operating the copy machine 100. A copy button 410 is a button used when the operator instructs the copy machine 100 to start copying documents. When the copy button 410 is pressed by the user, the operating portion 400 transfers the user's instruction to the copy machine 100. A display portion 420 formed of a liquid-crystal display or the like is provided

at a position on the operating portion 400 that is slightly to the left of the center of the operating portion 400. The display portion 420 is for displaying messages such as errors and instructions to the operator.

[0039]

Next, the electrical configuration of the copy machine 100 will be described with reference to Figs. 4 and 5. As shown in Fig. 4, a CPU 500, a ROM 510, a RAM 520, a screen drive portion 530, an input detection portion 540, the document detection sensor 221, the passage detection sensor 222, the print portion 330, the A/D converter 550, a compression/decompression portion 560, a binary processing portion 570, and a motor control portion 580 are connected to a bus 590.

[0040]

The CPU 500 is for controlling the copy machine 100. The ROM 510 is prestored with various programs to be executed by the CPU 500, various settings, and various initial values. The programs include: a copy program that will be described later with reference to Figs. 8 and 9. The RAM 520 is for temporarily storing data while the CPU 500 executes data processing. The screen drive portion 530 is for controlling the display portion 420, which is connected to the screen drive portion 530, to display data such as characters and images. The input detection portion 540 is for detecting the input of the copy button 410.

Other several switches and buttons, which are provided on the operating portion 400 although not shown, are also connected to the input detection portion 540.

[0041]

The A/D converter 550 is for converting the images that have been read in by the CCD image sensor 211 from the documents into digital data to be used as image data. The binary processing portion 570 is for turning tone information of the image data (value data on the brightness of each pixel) into binary data by converting the tone data into one-bit data by using a threshold value. The compression/decompression portion 560 is for performing compression (encoding) to reduce the amount of binary image data and for performing decompression (decoding) to return the compressed image data to the original, decompressed image data. Note that the compression/decompression portion 560 is equivalent to a "compression means" in accordance with the present invention.

[0042]

The motor control portion 580 is for controlling various components including: a CCD movement motor 581 for moving the CCD image sensor 211 in order to read in a document placed on the glass plate 212 (Fig. 2); a document feed motor 582 for driving the supply roller 214, the pressure roller 215, and the discharge roller 216 in the ADF 210, as well as other document feed rollers (not

shown); and a paper feed motor 583 for driving the paper supply roller 341, the paper discharge rollers 361, and the feed rollers 362, 363, and 364, as well as other paper feed rollers (not shown) in the image forming portion 300. The motor control portion 580 is further connected to other drive motors (not shown) for driving other drive components in the copy machine 100, such as the photosensitive drum 332 and the fixing unit 334 in the print portion 330.

[0043]

The storage area of the RAM 520 will be described. As shown in Fig. 5, the RAM 520 is provided with: a work area 521 used for data processing when the copy machine 100 operates; a document sheet counter storage area 522 in which are stored counters n and m for counting the numbers of documents read in; a recording request flag storage area 523 in which is stored a recording request flag for confirming whether or not a print command has already been sent to the image forming portion 300; a front-surface image data storage area 524 for storing image data for the front surfaces of the documents; and a rear-surface image data storage area 525 for storing image data for the rear surfaces of the documents. Although not shown in the figure, the RAM 520 is also provided with storage areas used by the CPU 500 when the CPU 500 executes the print program for printing and executes other data processes.

[0044]

Note that the front surface of a document is equivalent to "one surface of the document" in accordance with the present invention, and the rear surface thereof is equivalent to "the other surface of the document" in accordance with the present invention. Incidentally, the relationship between the front surface and the rear surface of a document is relative with respect to each other, but for the sake of simplicity the side of the document that is read in first by the image reading portion 200 during a document-reading stage (which will be described later) is assumed to be the front-surface of the document hereinafter. The RAM 520 is equivalent to a "storage means" in accordance with the present invention, and the front-surface image data storage area 524 and the rear-surface image data storage area 525 are equivalent to a "first storage area" and a "second storage area", respectively.

[0045]

The storage area of the RAM 520 is essentially divided into two sections. The first section is formed with the rear-surface image data storage area 525, while the second section is formed with all of the other remaining storage areas except for the rear-surface image data storage area 525. More specifically, the remaining storage areas other than the front-surface image data storage area 524 are reserved or secured in the second section with a remaining available area being allocated to

the front-surface image data storage area 524. Because the RAM 520 is thus partitioned into the two blocks, it is unnecessary to manage pointers for specifying the storage locations of image data that has been stored in each storage area. It is therefore possible to efficiently access the storage location of image data when writing the image data in and reading image data out from each storage area. The front-surface image data storage area 524 and the rear-surface image data storage area 525 are provided independently from each other in this manner. Image data is stored so as not to span the two storage areas 524 and 525. The front-surface image data storage area 524 is for storing data for the front-surface sides of the documents and has a variable storage capacity. The rear-surface image data storage area 525 is for storing data for the rear-surface sides of the documents and has a fixed storage capacity.

[0046]

The rear-surface image data storage area 525 has a storage capacity of image data that is to be read in from an image formed on one side (one surface) of one document. It is now assumed that the specifications of the copy machine 100 are such that the copy machine 100 can copy documents up to a maximum size of 8 inch by 10 inch, that one (1) bit of data quantity is required for each pixel, and that the copy machine 100 copies images at a resolution

of 600 x 600 dpi. In this case, the amount of data read in from the maximum sized document is (8 x 600) x (10 x 600) x 1 = 28,800,000 bits. A storage capacity of approximately 3.4 Megabytes is therefore required to store image data for one side of one document of the maximum size. In such a case, the storage capacity of the rear-surface image data storage area 525 is set to 3.4 Megabytes.

[0047]

In contrast thereto, the storage capacity of the front-surface image data storage area 524 is preferably larger than the storage capacity of the rear-surface image data storage area 525. In order to copy a plurality of documents while reducing the work of the operator, the copy machine 100 first reads in the images on the front sides of all the documents in succession, and reads in the images on the rear sides of the documents after image data for the front sides of all the documents has been stored in the RAM 520, as will be described later. For that reason, as the storage capacity of the front-surface image data storage area 524 becomes larger, the quantity of image data that can be stored together increases, and the number of documents that can be processed also increases.

[0048]

The copy machine 100 can compress image data, before storing the image data in the front-surface image data storage area 524 or the rear-surface image data storage

area 525. In such a case, the storage capacity of the rear-surface image data storage area 525 is set dependently on the compression ratio of the image data. It is now assumed that a compression engine employed by the compression/decompression portion 560 compresses image data from the rear surface of one document at a compression ratio of between 50% and 70%. In such a case, the storage capacity of the rear-surface image data storage area 525 can be decreased to a value of 70% of the original storage capacity. Similarly, when the image data from the front surfaces of the documents is compressed, it is possible to increase the original quantity of the image data that can be stored in the front-surface image data storage area 524. It is possible to increase the number of documents that can be processed at a time.

[0049]

Next will be described with reference to Figs. 1 through 7 how the copy machine 100 performs copying operation. In this case, three documents are originally stacked as indicated by a state C in Fig. 6 and are placed on the supply tray 220. The image on the front surface of the uppermost document sheet is denoted by I, the image on the rear surface thereof is denoted by II, the image on the front surface of the second document sheet is denoted by III, the image on the rear surface thereof is denoted by IV, and the image on the front surface of the third (lowermost)

document sheet is denoted by V, and the image on the rear surface thereof is denoted by VI. Other states D, E, and F are similar. The upper direction in each image is indicated by an arrow. The upper side of each of the stacked documents is indicated with a solid line whereas the under side thereof is indicated with a broken line. States G, H, J, K, L, M, and N in Fig. 7 are similar.

[0050]

In order to produce a copy product of the plurality of documents with images formed on both sides thereof, all the images on the front surfaces of the documents are first read in sequentially by the image reading portion 200 (Fig. 1). The reading of these documents starts being executed when the operator presses the copy button 410 after locating the document stack on the supply tray 220. The images on the front surfaces of the documents are read in by the document detection sensor 221 (shown in Fig. 2) as the documents are fed through one at a time by the ADF 210.

[0051]

More specifically, the uppermost document in the stack on the supply tray 220 (as shown in the state C of Fig. 6) is fed through in a state in which the front surface (the surface with image I of Fig. 6) faces the curved surface of the feed path 213 shown in Fig. 2. The front surface confronts the CCD image sensor 211 via the glass plate 212, and the image I on the front surface is

read in line by line. After passing the CCD image sensor 211, the document is discharged on the discharge tray 230 with its front surface with image I facing downwardly. Subsequently, the images III and V on the front surfaces of the remaining documents are read in in the sequence in which the documents are stacked, in a similar manner as described above, and are discharged on top of the previous document to produce a stack of documents as in the state D of Fig. 6. In this manner, image data of the images on the front surfaces of the documents is stored in the front-surface image data storage area 524 in the RAM 520 in the sequence in which the image data has been read in from the corresponding documents.

[0052]

Viewing an instruction displayed on the display portion 420, the operator sets the documents that are now stacked on the discharge tray 230 back onto the supply tray 220 while maintaining unchanged the orientation and the stacking direction of the documents. As a result, the documents are set on the supply tray 220 in the state E of Fig. 6. In state E, the documents are stacked in the opposite stacking order from the state when the front surfaces of the documents have been read in. The operator then presses the copy button 410 to instruct the copy machine 100 to start the reading of the rear surfaces of the documents in sequence from the top in the stack order.

As a result, the images VI, IV, and II on the rear surfaces are read in in the same manner as the front surfaces. The documents are then sent out onto the discharge tray 230 as in state F of Fig. 6.

[0053]

According to the copy machine 100, the printing of a copy product of each document that has a rear surface that is being read in is executed at an arbitrary timing by the print portion 330 in parallel with the reading of that document. The printing is started in response to a print start command (hereinafter called a "recording request") that is outputted from the copy program that will be described later with reference to Figs. 8 and 9. The copy program manages the timing at which the recording request is outputted in such a manner that images based on image data for the front side and the rear side of each document are formed by the print portion 330 simultaneously when the image data for the rear surface of the subject document is being stored into the rear-surface image data storage area 525.

[0054]

Image data that has already been printed is no longer necessary. Accordingly, when image data for the rear surface of one document is newly read in, the rear-surface image data storage area 525 that is now stored with already-printed image data for the rear surface of a

previous document is overwritten by the image data for the present document. Once the copying based on the present document has ended, the storage area 525 is again overwritten by the image data for the rear surface of the next document that is newly read in (Fig. 6). Thus, in contrast to other types of copy machine in which printing starts only after images have been read from the front surfaces and rear surfaces of all the documents, the copy machine 100 of the present embodiment releases the storage area, which is occupied with image data that has already been printed, and stores image data for the next document in the released, now available area. The rear-surface image data storage area 525 does not need storage capacity for holding image data for the rear surfaces of all the documents.

[0055]

The image forming portion 300 is provided with the double-sided print mechanism and is capable of printing image data for both sides of each document onto both sides of a sheet of paper in response to a corresponding recording request. The image forming portion 300 starts printing, as shown in Fig. 3, when a recording request is issued. Then, one of papers stacked in the paper supply cassette 310 (state G of Fig. 7) is fed to the print portion 330 by the paper supply roller 341 and along the feed paths 340 and 345. In the print portion 330, a front

surface of the sheet of paper that now faces the photosensitive body 332 is printed with an image (image V of Fig. 7) (state H in Fig. 7), and is sent out along the feed path 350 by the paper discharge rollers 361 onto the paper discharge tray 320 (state J of Fig. 7).

[0056]

When the trailing edge of the paper reaches the position of the paper discharge rollers 361, the paper discharge rollers 361 starts rotating in the opposite direction, pulling the paper back into the image forming portion 300. The trailing edge of the paper is guided toward the feed path 360, which is provided at a different position from the feed path 350, and is again guided along the feed path 360 (state K of Fig. 7) to the print portion 330 (state L of Fig. 7). The passage along the feed path 360 turns the paper so that the rear surface of the paper that is opposite to the front surface on which the image V has been formed faces the photosensitive body 332. Another image (image VI) is then formed by the print portion 330 on the rear surface (state M of Fig. 7), and the paper is sent out to the paper discharge tray 320 by the paper discharge rollers 361 along the feed path 350 (state N of Fig. 7).

[0057]

The previously-read images of the front surfaces of the documents (image III and I in Fig. 6) and the corresponding images for the rear surfaces (IV and II in

Fig. 6) are each printed as respective pairs in a similar manner when the corresponding images for the rear surfaces (IV and II in Fig. 6) are read in, and the completed copies are stacked on top of the paper that has been discharged previously onto the paper delivery tray 320 (state N in Fig. 7).

[0058]

When the copy machine 100 of this embodiment is used to copy a plurality of documents having images formed on both sides, the images on the front surfaces of all the documents are read in first, and then the reading of the rear surfaces of the documents is done, in a similar manner to that described previously. During this time, the necessary storage capacity can be reduced and the time taken by the copying process can be shortened by managing the storage and usage of the image data in accordance with the copy program (see Figs. 8 and 9). Since the sequence in which the image data is printed is also managed, the operator obtain copies that are arranged in the same order as the original documents. The description now turns to the management of the image data based on the copy processing, in accordance with the flowcharts of Figs. 8 and 9 and with reference to Figs. 2 to 7, and 10. Note that each step in the flowcharts is abbreviated to "S".

[0059]

It is noted that the copy program is prestored in a

predetermined storage area of the ROM 510. The CPU 500 executes the copy program when the operator selects the mode for double-sided copying. The copy program is installed not only in the copy machine 100 but also in: other types of copy machines and multifunction devices that read in both sides of documents and print the read-in images onto both sides of papers to produce a copy of the documents; and other devices that read in both sides of documents and output files, in formats such as PDF, that can be used by electronic computers. Accordingly, various settings can be performed for an image data processing method employed in the copy program. These settings include whether or not there is compression of the image data, the print sequence based on the specifications of the image forming portion (such as face-up delivery or face-down delivery), and the storage capacities necessary for the front-surface image data storage area 524 and the rear-surface image data storage area 525. For that reason, the setting for the image data processing method, based on the unique configuration of the copy machine 100 of this embodiment (hereinafter called a "machine-specific setting") is stored in a predetermined storage area of the ROM 510.

[0060]

The double-sided copying is started when the operator stacks, on the supply tray 220, a plurality of document

sheets (three document sheets shown in Fig. 6 in this example) formed with images on their both sides and then presses the copy button 410 (fig. 1). When the copy program is started being executed, first, as shown in Fig. 8, initialization is executed in S11. The initialization includes: allocating the various storage areas in the RAM 520 according to the machine-specific settings; setting to zero (0) the counters n and m in the document sheet counter storage area 522; and setting off the recording request flag in the recording request flag storage area 523.

[0061]

Next, in S12, the document detection sensor 221 is controlled to check whether or not there are any documents on the supply tray 220. If there are no documents on the supply tray 220 (NO in S12), a message is displayed on the display portion 420 to inform the operator that there are no documents on the supply tray 220 in S13. An end processing is then performed in S86 (Fig. 9), in which the storage areas secured in the RAM 520 for the copy program are released, and the copy program ends.

[0062]

If the document detection sensor 221 detects some document on the supply tray 220 (YES in S12), the CPU 500 executes in S15 a memory check to check the storage capacity which has been allocated for the front-surface image data storage area 524 and the rear-surface image data

storage area 525 during the initialization process of S11. Then, the CPU 510 determines in S16 based on the result of the check in S15 whether or not the minimum usable operating memory is available. The CPU 510 executes this determination by determining whether or not the storage capacities of the front-surface image data storage area 524 and the rear-surface image data storage area 525 are each greater than the storage capacities that have been stored in the ROM 510 as the machine-specific setting. Note that the CPU 500 that checks the storage capacities of the front-surface image data storage area 524 and the rear-surface image data storage area 525 in the determination of S16 is equivalent to a "verification means" in accordance with the present invention.

[0063]

If any of the storage capacity of the front-surface image data storage area 524 and the rear-surface image data storage area 525 is less than the corresponding storage capacity set as the machine-specific setting (NO in S16), the CPU 500 determines that sufficient storage capacities have not been allocated through the initialization processing of S11. Accordingly, in S17, a message or the like is displayed on the display portion 420 to inform the operator that there is no memory. Then, the end processing is executed in S86, and the copy program ends.

[0064]

On the other hand, if it is determined that the storage capacities of the front-surface image data storage area 524 and the rear-surface image data storage area 525 are greater than or equal to the minimum usable storage capacities (YES in S16), the CPU 500 increments the value of the counter n by one (1) in S21 to execute the process of "n=n+1" (. Then, the front-surfaces of the documents. stacked on the supply tray 220 are read-in by the loop of S21 to S36. The counter n indicates that number of the documents that is now being read in. Because zero (0) has been set to the counter n during the initialization of S11, when the processing of S21 is first executed, the value of the counter n becomes one (1).

[0065]

Next, in S22, the reading in of the front surface of the n-th document from the top of the stack starts (S22). The document is fed in and the image formed on the front surface of the n-th document (image I on the front surface of the first document in state C of Fig. 6) is read in one line at a time by the CCD image sensor 211. The image data that is outputted from the CCD image sensor 211 is converted into digital data by the A/D converter 550. The digital data is converted by the binary processing portion 570 into binary values, after being subjected to image processing, such as shading correction or character emphasis, although not shown in the drawings. If the

binary-form image data is to be compressed as specified by the machine-specific setting (YES in S23), compression of the image data is executed by the compression/decompression portion 560 in S25. If compression of the image data is not executed, the process proceeds to S31.

[0066]

Whether or not the image data is compressed depends on the relationship between the storage direction of the image data while the image data of the documents that has been read in by the image reading portion 200 is stored in the RAM 520 (see Fig. 6) and the reading out direction of the image data while the print portion 330 is forming images based on the thus-stored image data (see Fig. 7). Taking the image V on the third document in state C of Fig. 6 as an example, the image is read line-by-line from the top to the bottom (hereinafter called the "normal direction") and is stored in the front-surface image data storage area 524 in the sequence in which each line was read in the normal direction. If the stored image data for this image V is read out line-by-line in the same direction as the storing direction (see Fig. 7) when it is being printed by the print portion 330, it can be decompressed easily even if it was stored in the RAM 520 after being compressed (because the data can be decompressed in the same direction as that of the data when it was being compressed). However, if the reading out of the image V is

done in opposite order from that in which the lines were stored, it can not be decompressed easily and thus it is necessary to provide a storage area for performing this decompression, which has the perverse effect of necessitating a larger storage capacity.

[0067]

With the copy machine 100 of this embodiment, since the storage direction (see Fig. 6) and the reading out direction (see Fig. 7) is the same for both the image data for the front surfaces of the documents and the image data for the rear surfaces of the documents, it is possible to compress the image data. However, if the copy program has been used in other multifunction devices or copy machines as described above, the unique configurations of those devices could mean that the storage direction of the image data for the front surfaces and the image data for the rear surfaces of the documents does not match the reading out directions thereof, so that it is possible to select whether or not the image data is to be compressed, as the machine-specific setting. Even in this copy machine 100, the operator can also select a configuration in which the images on the front surface and the rear surface are in mutually different directions, so that when this selection is made it is necessary that the direction in which image data is read out during printing differs from the direction in it was stored when read in, thus requiring a

setting in which compression is not done.

[0068]

The compressed image data is stored in the front-surface image data storage area 524 (S32). The CPU 500 checks beforehand whether or not there is space in the storage capacity of the front-surface image data storage area 524 used as memory for storing the front surfaces (S31). This is to make it possible to handle situations such as when there is a large number of documents, so that if the storage capacity just for enabling the storage of the image data for all the documents cannot be reserved as the front-surface image data storage area 524, the print processing is done for the image data for the documents that have been read in up to that point, excluding the image data of documents of the portion that cannot be stored. On the other hand, if there exists some available space in the front-surface image data storage area 524 (YES in S31), image data (compressed or non-compressed image data) for the read-in documents is stored in S32.

[0069]

While the storage of image data for one document that is presently being read in line-by-line is not yet complete (NO in S33), the flow returns to S22 and the reading of the present document continues. As described already, the leading and trailing edges of the document in the feed direction are detected by the passage detection sensor 222

as the document is being fed. In the determination processing of S33, the CPU 500 determines whether or not the storage of image data for one document has been completed by determining whether or not a predetermined period of time has passed after the trailing edge of the document has been detected by the passage detection sensor 222. The predetermined period of time is the total of: a period of time from when the trailing edge of the document passes the passage detection sensor 222 until the trailing edge of the document passes the CCD image sensor 211; and another period of time required to process image data of the document that has been read in by the CCD image sensor 211 and then to store the image data in the front-surface image data storage area 524. The predetermined period of time is determined previously by experiments.

[0070]

While the reading in of the document is continuing in the loop of S22 to S33, if there exists no more available space in the front-surface image data storage area 524 (NO in S31), a message or the like is displayed on the display portion 420 in S41 to inform the operator that the processing is interrupted due to insufficient memory. Next, in S42, the CPU 500 refers to the present value in the counter n. If the present value of the counter n is equal to one (1), it is known that the memory insufficiency has occurred during the reading in of the front surface of the

first document (YES in S42). The CPU 500 therefore determines that the double-sided printing is impossible. The copy program ends after passing through the end processing of S86 (Fig. 9). It is noted that the memory insufficiency will possibly occur while the front surface of the first document is being read in as described below. The memory insufficiency will possibly occur if the first document is relatively long and the size of the first document is greater than the maximum size of documents assumed by the machine-specific setting for the copy machine 100. The memory insufficiency will possibly occur also if the machine-specific setting sets that image data compression should be executed and if the document compression ratio, at which the compression/decompression portion 560 actually compresses image data, is lower than a compression ratio assumed by the machine-specific setting.

[0071]

On the other hand, if the reading in of the front surface of the first document is completed without generating a memory insufficiency (YES in S33), the present value of n is stored in S35 in the front-surface image data storage area 524 together with the image data for the subject document that has just been read in and stored. In other words, the image data that has just been stored in the storage area 525 is linked with the number n that indicates the order of the document, from which the image

data has been read in, from the top of the stack.

[0072]

The CPU 500 then checks in S36 whether or not the reading of all the documents has been completed by controlling the document detection sensor 221 to check whether or not there remain any documents on the supply tray 220. If there still remain some document (NO in S36), the flow returns to S21, where the counter n is incremented by one (1), and the front surface of the next document is read in in the same manner as described above by the loop of S22 to S33. In the example shown in Fig. 6, the image III on the front surface of the second document in state C is read in, followed by the image V on the front surface of the third document. On the other hand, if all of the documents stacked on the supply tray 220 have been read in and no documents remain on the supply tray 220 (YES in S36), the flow moves on to the processing of S51 in Fig. 9. Note that the CPU 500 that controls the reading of the images formed on both sides of the documents, by the loops of S21 to S36 and S56 to S83, which will be described later, is equivalent to an "reading control means" in accordance with the present invention.

[0073]

When a memory insufficiency occurs while the second or subsequent document is being read (NO in S31 and NO in S42), the display portion 420 is controlled in S43 to

display a decision request to confirm whether the operator wishes to continue the double-sided copying of the documents that have already been read in. If the operator instructs the cancellation of the double-sided copying by operating a predetermined button on the operating portion 400 (NO in S45), the end processing is performed in S86, and the copy program ends without performing the double-sided copying.

[0074]

On the other hand, if the operator manipulates the operating portion 400 to instruct the copy machine 100 to perform double-sided copying of the documents that have been read in so far (YES in S45), the image data for the n-th document, for which reading has not been completed, is cleared or destroyed in S46. In other words, image data in the front-surface image data storage area 524 that has not yet been linked to a value of the counter n by the processing of S35 is destroyed. Next, in S47, the CPU 500 decrements the value of the counter n by one (1), and the flow proceeds to S51 of Fig. 9.

[0075]

When the reading of the front surfaces of the documents has been completed as shown in Fig. 9, the display portion 420 is controlled in S51 to display a report asking the operator to reposition the documents and to input his/her instruction to start the reading of the

rear surfaces. The display continues until the copy button 410 is pressed (NO in S52). Viewing the report on the display portion 420, the operator repositions the documents that are now on the discharge tray 230 (state D in Fig. 6) onto the supply tray 220, while maintaining unchanged the stack direction of the documents and the orientation of the images (state E in Fig. 6). In this manner, by repositioning the documents without reversing their orientation and their stacking direction, the documents are stacked on the supply tray 220 so that the rear-surface images VI, IV, and II face upwardly and are arranged in sequence from the top.

[0076]

When operator has completed this repositioning and has pressed the copy button 410 (YES in S52), the CPU 500 checks in S53 whether or not there is some document on the tray 220 by using the document detection sensor 221. If no documents are detected by the document detection sensor 221, it is determined that there are no documents (NO in S53), and the display portion 420 is controlled in S55 to display a report informing the operator that there are no documents. The flow then returns to the determination processing of S51.

[0077]

If some document is placed on the supply tray 220 (YES in S53), the value of the counter m is incremented by

one (1) to perform the process "m=m+1" in S56. The counter m indicates that an m-th document from the top of the present stack is currently being processed in the loop of S56 to S83. The value of zero (0) has been set into the counter m during the initialization of S11. Accordingly, when the processing of S56 is first executed, the value of the counter m becomes 1.

[0078]

The CPU 500 then determines in S57 whether or not m is smaller than or equal to the present number of the counter n. The processes of S57 is for performing a check and for informing an error in situations such as if the operator has intended to start the reading of the rear surfaces but has added a new document by mistake to the stack so that the number of documents has increased; or if the double-sided copying of documents that have been read in has ended, even though the front surfaces of some documents were not read because of a storage capacity insufficiency, but the operator fails to remove the documents, for which the reading of the front surfaces has not been executed, and the reading of the rear surface of the not-removed documents are executed (yes in S45, S46, S47). These situations make the judgment in S57 negative, and an error message is displayed in S58 on the display portion 420. The error message is displayed in S58 on the display portion 420 to inform that there is an abnormality

in the number of documents on the rear surface side. After the process of S58, the flow proceeds to S85. In this example, the value of the counter m is one (1) when the processing of S57 is executed first, and the value of the counter n has become three (3) because the front surfaces of the three documents have been completely read, so that the m is smaller than or equal to n (YES in S57).

[0079]

Next, in S61, the CPU 500 checks whether or not there exists an available space of a certain amount in the rear-surface image data storage area 525 serving as an original rear-surface storage memory. The determination processing of S61 is intended to check, even after the reading in of the rear surface has started, an available space in the rear-surface image data storage area 525 and to confirm whether the available area presently existing in the rear-surface image data storage area 525 has at least a minimum amount that is required to store the image data.

[0080]

As mentioned above, the copy program can be installed not only in the copy machine 100 but also in other types of copy machines and multifunction devices. In some device, it is impossible to allocate a storage capacity equivalent to one page's worth of image data for the maximum size document to the rear-surface image data storage area 525. The copy program of the present embodiments can cope with

such a device. While an image of a document is being read in line one by one, image data for a newly-read-in line is stored in the rear-surface image data storage area 525 by being overwritten over image data that has already been printed. The storage area 525 with the small storage capacity is thus used highly efficiently.

[0081]

In such a device, however, if the image read-in speed is faster than the print speed, image data that is stored in the rear-surface image data storage area 525 but that has not yet been printed by the image forming portion 300 will possibly be overwritten by newly-read-in image data. The not-yet-printed image data will be lost. The copy operation is performed improperly. If the minimum required amount determined previously based on experiments is not secured in the rear-surface image data storage area 525 (NO in S61), the determination processing of S61 is repeated until the required minimum amount is secured in the rear-surface image data storage area 525.

[0082]

When the certain amount of available area exists in the rear-surface image data storage area 525 (YES in S61), the program proceeds to S63, where based on the value of the counter m, reading of the rear surface of the m-th document from the top of the stack starts. As shown at state E in Fig. 6, the image VI on the rear surface of the

first document is read in first. Since the repositioning from state D to state E does not change the orientation or the stacking direction of the documents, the image VI is read in line-by-line in the direction from the bottom to the top of the image (hereinafter called the "reverse direction"). The image data for the respective lines of the image VI will be stored in the rear-surface image data storage area 525 in the sequence in which the lines have been read in in the reverse direction.

[0083]

In the same manner as described above for the front surfaces, the read-in image data is subjected to image processing (not shown in the drawings), is converted into binary data, and is then subjected to data compression, by the compression/decompression portion 560 (YES in S65, S66). According to the present embodiment, the image data for the rear surface of each document will be read out from the storage area 525 in the same line-by-line sequence as the line-by-line sequence in which the image data is stored in the storage area 525. Accordingly, the image data is compressed. Note that if compression is not specified by the machine-specific setting (NO in S65), the flow proceeds from S65 directly to S71. If some available area exists in the rear-surface image data storage area 525 serving as the rear surface memory (YES in S71), the newly-read-in image data is stored in S75 in the rear-surface image data

storage area 525.

[0084]

It is noted that while the rear surface of a document is being read in during the loop of S63 to S81, it will possibly happen that there exists no available part in the rear-surface image data storage area 525 (NO in S71). This corresponds to the cases such as if the operator replaces an original document so that a copy is created with the same front surface but different rear surfaces, or if the read-in image data increases because a longer document than the previous one is substituted. However, since the image data that is stored in the rear-surface image data storage area 525 is compressed, it could be possible to read in a longer document so that image data that exceeds the quantity of image data for the rear surface of the previous document is stored. If this is while the image forming portion 300 is printing, there will still be some unused image data in the rear-surface image data storage area 525. If the memory is released by using that image data, the storage capacity of the rear-surface image data storage area 525 will once again become free. If area for storing the data can be reserved by this method (YES at S72), the flow returns to S71 and the processing of S71 and S72 is repeated and the processing waits until that area can be reserved.

[0085]

On the other hand, if the size of the rear surface is too large or if compression ratio for the image data is worse than that expected, therefore, it might not be possible to reserve the data storage areas even after releasing memory as described above (NO at S72), a message or the like is displayed on the display portion 420 to inform the operator that processing is interrupted due to insufficient memory in S73. The flow then proceeds to S85.

[0086]

If the image VI on the first rear surface is read in without any memory insufficiencies and image data of the image VI is stored in S75, the CPU 500 checks in S76 whether or not a recording request has already been issued to the image forming portion 300, by checking the status of the recording request flag that is stored in the recording request flag storage area 523. If the recording request flag is in an off condition and therefore no recording request has yet been issued (NO in S76), the CPU 500 checks in S77 whether or not a certain amount of image data that has been read in and has been stored in the storage area 525.

[0087]

In the copy machine 100 of this embodiment, printing of a copy of one double-sided document is executed by the image forming portion 300 in parallel with the reading in of the rear surface of the subject document. At that time,

the image data stored in the rear-surface image data storage area 525 is read out and used. Printing in this image forming portion 300 is done by a laser recording method. In order to protect the high-voltage-charged photosensitive drum 332 from being damaged, temporal stopping of the printing is impossible, and once the image forming portion 300 has started printing onto one sheet of paper, the image forming portion 300 is prohibited from stopping the printing temporarily. If the quantity of image data that is read out from the storage area 525 exceeds the quantity of image data that has been stored in the storage area 525 based on reading in operation of the image reading portion 200, no image data remains in the storage area 525. Image data runs out from the storage area 525. In such a case, no information (a so-called NULL) will be printed on the paper.

[0088]

According to the embodiment, in order to prevent the data running-out problem, the copy program is designed to manage a printing start timing based on the relationship between the speed at which read-in image data is stored in the storage area 525 in accordance with the image reading portion 200 and the speed at which image data is read out from the storage area 525 in accordance with printing by the image forming portion 300 so that image data does not run out from the storage area 525. As will be described

later, the copy machine 100 of this embodiment first prints out the image data for the front surface of the document that has been read-in first, then prints out the image data for the rear surface that is linked to that image data, to ensure that the printed sheets of paper are delivered to the tray 320 after the copy processing in the same order they were arranged in.

[0089]

Fig. 10 shows a graph indicative of a relationship between an image data storing speed and an image data read-out speed. The horizontal axis indicates a time (t), while the vertical axis indicates quantity (q) of image data. This graph compares the relationships between a line segment 200a that shows the storage speed at which the image data for the rear surface of the document, which has been read in by the image reading portion 200, is stored in the rear-surface image data storage area 525, and line segments 300a, 300b, and 300c that show the read-out speeds while image data that is stored in the front-surface image data storage area 524 and the rear-surface image data storage area 525 is being read out and printed by the image forming portion 300. Note that, the image data read-out speed is faster than the image data storing speed.

[0090]

A data quantity Q1 denotes the quantity of image data that has been already read in from the front surface of one

document. A data quantity Q2 denotes the total quantity of image data read in from the front surface and the rear surface of the subject document. It is assumed that the image data is not compressed. The front surface and the rear surface have a fixed same size. The quantity Q2 is therefore equal to twice the data quantity Q1. The read-in speed, at which images are read in from documents by the image reading portion 200 can be determined previously by experiments or the like. Accordingly, it is possible to determine the image data storing speed, at which the read-in image data is stored in the rear-surface image data storage area 525. When the read-in image data from the rear surface of the document starts being stored in the storage area 525 at a time T2. It is possible to estimate, based on the image data storing speed of the line segment 200a, that the entire image data from the rear surface will be completely stored at a time T7 and that the storing into the storage area 524 will be completed.

[0091]

Similarly, the printing speed, at which images are printed on both sides of a sheet of paper can be determined by experiments or the like. It is therefore possible to determine the image data read-out speed, at which image data is read out from the storage areas 524 and 525 for printing. When the image data for the front surface starts being read out from the storage area 524 at a time T0. It

is possible to estimate, based on the image data read-out speed, that the entire image data for the front surface will be completely read out at a time T4, that the image data for the rear surface starts being read out in succession, and that the entire image data for the rear surface will be completely read out at a time T6.

[0092]

In the image forming portion 300, the image data for the front surface is used first. At the time T4, the printing based on the front surface of the document is completed, and the printing based on the remaining rear-surface image data starts. The reading in of image data by the image reading portion 200 with the processing of S21 to S36 (see Fig. 8) for the front surface of the document is completed also a quantity of image data (Q1a - Q1) that is the difference between the data quantity Q1a and the data quantity Q1 has been read in for the image data of the rear surface. In other words, at that time T4, a quantity of image data (Q1a - Q1) has not yet been used by the image forming portion 300, so the above-described state in which data has run out does not occur. The segment 200a indicating storage speed and the segment 300a indicating read-out speed subsequently intersect at a time T5. This means that, at any time from T4 onwards, the total quantity of image data used by the image forming portion 300 up to that time is greater than the total quantity of image data

read-in by the image reading portion 200 up to that time. In other words, from T5 onward, the image data could run out.

[0093]

To prevent such a situation, the determination processing of S77 of the copy program ensures that printing of the image data does not start until a predetermined quantity of image data is stored in the rear-surface image data storage area 525 (NO at S77), so the flow returns to S63 and the reading in of the document continues. As shown in Fig. 10, this delays the start of printing by the image forming portion 300, based on the estimated times at which the above-described processes end, by selecting a line segment such as the line segment 300b indicating read-out speed, to ensure that the line segment 200a indicating storage speed does not intersect the line segment 300a indicating read-out speed. Referring to the line segment 300b indicating read-out speed makes it possible to stop the print data running out, by delaying the print start time from the time T0 to the time T1, and thus delaying the print end timing from the time T6 to the time T7.

[0094]

The line segment 300b indicating read-out speed synchronizes the end time for image read-in and the print end time (time T7) and indicates the ideal print start time (time T1). Note that the configuration could be such that

the reading in of the image of the rear surface of the document starts (time T2) after a predetermined time has elapsed from the start of printing by the image forming portion 300 (time T1).

[0095]

However, if the timing of print start could be adjusted with reference to the timing at which a predetermined quantity of image data has been stored in the rear-surface image data storage area 525, as in this embodiment, it would be possible to prevent the image data running out, without providing timer means for measuring the relevant timings. For example, the line segment 300c indicating print speed causes the start time of printing to be delayed so that printing starts from a time T3 at which a quantity (Q1b - Q1) of the image data has been stored in the rear-surface image data storage area 525. In that case too, the end point of printing can be delayed until after the end point of the reading in of the image, making it possible to prevent the image data running out. Note that in this example, the end point of printing can be delayed until after the end point of the reading in of the image, even if the data quantity (Q1b - Q1) is zero.

[0096]

On the other hand, when the amount of image data presently stored in the rear-surface image data storage area 525 reaches the amount previously determined according

to the experiment and set as machine-setting (YES in S77), the CPU 500 issues in S78 a recording request for instructing the start of printing to the image forming portion 300. When the recording request is issued, the recording request flag is turned ON to indicate that a recording request has already been issued.

[0097]

After the start of reading in of the image VI from the rear surface of the first document and while the storing of the entire image data from the rear surface of the first document has not yet been completed (NO in S81), the flow returns to S63 and the reading in of the rear surface of the subject document continues. Whether or not storing of the entire image data of the rear surface of the subject document has been completed is determined based on the detection of the leading edge and the trailing edge of the document by the passage detection sensor 222 in the same manner as described above. Note that after the recording request has been issued in S78 in the loop of S63 to S81, the determination processing of S76 shows that the recording request flag is on (YES in S76), so the flow proceeds directly to S81.

[0098]

When the reading in of the rear surface of the first document has been completed (YES in S81), the recording request flag is turned off in S82 in preparation for

printing the next document. The CPU 500 then checks in S83 whether or not there remain any documents on the supply tray 220 based on the detection by the document detection sensor 221, and determines whether or not the reading in of all the documents has been completed. If there remains some document on the supply tray 220 (NO in S83), the flow returns to S56, wherein the counter m is incremented by one (1), and the image IV (see Fig. 6) on the rear surface of the next document is read in by the loop of S63 to S81, in the same manner as described above. After the image IV of the rear surface of the second document has been read in, the image II of the rear surface of the third document is read in in the same manner as described above, and, when all of the documents that have been placed on the supply tray 220 have been read in and no documents remain on the tray (YES in S83), the flow proceeds to S85.

[0099]

As described above, the printing based on the recording request in the image forming portion 300 is executed in accordance with print processing performed in parallel with the reading in of the document by the image reading portion 200, but the copy program does not perform end processing for the copy processing and waits until the recording of the image data on the paper based on the previously issued recording request (in other words, the printing) has ended (NO at S85). When the copy program

receives from the print process the report that printing has completed (YES in S85), an end processing is executed in S86. The storage areas that have been secured in the RAM 520 for the copy program are released, and the copy program ends.

[0100]

In this manner, the copy processing is performed in accordance with the copy program but the print processing is performed in accordance with a print program that is not shown in the figures. The print program waits for a recording request that is issued by the copy program and the printing of the image data indicated by the recording request is started when the recording request is received. The recording request includes information such as on the page of the document to be printed. Information on the page to be printed is information such as the sequence of printing of the rear surface of the document that is being read in and the corresponding front surface, and where the image data is stored.

[0101]

As shown in Fig. 7, the copy machine 100 causes the image that has been printed on the upper surface of the document (such as the image VI in state M) to be delivered face downward (image VI in state N) into the paper delivery tray 320 (see Fig. 3). Since the next sheet of paper to be printed is stacked on top of the paper that was delivered

previously, it is important to decide which of the image on the front surface of the document or the image on the rear surface thereof should be printed first, and whether the printing should be done in the same sequence as the original documents or in the reverse sequence, when arranging the paper (state N) that has been printed in the same state as the sequence of the original documents (state C in Fig. 6).

[0102]

With this embodiment, the copy program of the copy machine 100 inserts information as to which image data to print, into the recording request that is issued by the processing of S78 (see Fig. 9). The position, from the start of the reading in of the rear surfaces of all the documents, of a document whose rear surface is to be read at a certain time is obtained from the counter m. In this example, from consideration of state C before the images on the front surfaces of the documents are read and state E before the images on the rear surfaces of the documents are read, as shown in Fig. 6, it is clear that in state C the documents are read in the sequence in which the documents are arranged whereas in state E they are read in the opposite sequence. In other words, the image data of the front surface of the document that corresponds to the image data of the rear surface of the nth document is considered to be the image data that has been linked the value of the

counter n recorded by the processing of S33 (see Fig. 8), which matches the value obtained by adding 1 to the maximum value of the counter m (the value of the counter m at the time when the reading of the front surfaces of all the documents has been completed (YES in S36)) to obtain a total and then by subtracting the value of the counter n at a certain timing from the total. In this manner, the image data for the front surface of the document is linked to the image data for the rear surface thereof, and also a specification of which among the image of the front surface of the document or the image of the rear surface is to be printed first is saved as a machine-specific setting, for each type of machine the copy program is installed in. A recording request having this decision as a variable is issued with respect to the image forming portion 300.

[0103]

Note that the CPU 520 that controls the issue of the recording request by the processing of S78, based on the result of the determination processing of S77 is equivalent to an "image forming control means" in accordance with the present invention. In addition, if the image data has been compressed before storage in the storage areas by the processing of S25 and S65, it would be apparent that the compressed image data is decompressed by the compression/decompression portion 560 (see Fig. 4) before being used in the forming of images during the printing by

the image forming portion 300, based on the recording request.

[0104]

As described above, the copy machine 100 of this embodiment first reads in images of all the front surfaces of a plurality of documents, stores that image data, then reads in images of the rear surfaces. With this reading in of the rear surfaces, the printing by the image forming portion 300 proceeds in parallel with the reading in of documents by the image reading portion 200 by the issue of a recording request that causes the printing of a pair of images based on the thus-read image data for the rear surface of the document and image data for the front surface that is linked to that image data, for each document that is read in.

[0105]

By starting the printing after the reading of the rear surface of the document has produced a predetermined quantity of image data that has been stored in the rear-surface image data storage area 525, it is possible to prevent a situation that would occur if the speed at which the copy is printed is faster than the speed at which the document is read, such that the image data runs out. The copy program can be made compatible with other types of copy machine and multifunction devices, not just the copy machine 100, by including a setting that is based on the

unique configuration of that machine as a machine-specific setting in the device in which the copy program is installed and by judging in each step of copy program.

[0106]

Note that, it would be apparent that various changes and modifications may be made therein. The image forming portion 300 may employ an ink-jet recording method instead of the known laser recording method. When employing the ink-jet recording method, the image forming portion 300 can halt print operation temporarily after the image forming portion 300 prints one line's worth of image data before printing the next line's worth of image. The image forming portion 300 can therefore stop printing temporarily when image data runs out from the data storage area. In the above description, image data already stored in the storage areas 524 and 525 is overwritten by newly-read-in image data. However, image data already stored in the storage areas 524 and 525 may be deleted after being printed out. The newly-read-in image data is then written into the storage areas.

[0107]

In the above description, the front-surface image data storage area 524 is provided together with the remaining storage areas other than the rear-surface image data storage area 525 in the same block and has a variable storage capacity. However, the front-surface image data

storage area 524 may be provided in another block which is independent from other storage areas similar to the rear-surface image data storage area 525. The front-surface image data storage area 524 may have a fixed amount of storage capacity. With this configuration, it is unnecessary to delete each line's worth of image data every time the subject line's worth of image data is printed. It is unnecessary to specify each storage location of each line's worth of data. It is possible to improve processing efficiency.

[0108]

The front-surface image data storage area 524 and the rear-surface image data storage area 525 could also be reserved without partitioning the RAM 520. In the above description, the front-surface image data storage area 524 and the rear-surface image data storage area 525 are reserved during the initialization processing of S11. However, the storage areas 524 and 525 may be reserved dynamically. In other words, during the initialization processing of S11, only the storage areas other than the storage areas 524 and 525 are reserved in the RAM 520. Image data are read in from the front surfaces of all the documents and is stored in an available space in the RAM 520. The remaining available space is allocated for the rear-surface image data storage area 525. By executing the processings of S15, S16, S31, S61, and S71, it is possible

to check the amount of the available area. It is possible to check whether an error occurs due to an insufficient storage capacity. By securing the storage areas dynamically, it is possible to allocate a large amount of storage capacity to the rear-surface image data storage area 525. It is possible to read in image data from the rear surfaces of several documents and to store the image data altogether in the storage area 525, thereby improving the processing efficiency.

[0109]

The storage capacity of the rear-surface image data storage area 525 was described above as being sufficient for storing image data for one surface of one document, but it is not necessarily limited thereto. For example, it could have the same storage capacity as the front-surface image data storage area 524, making it possible to read in the image data for the rear surfaces of all the documents continuously in a batch. Note that the timing of print start in this case would be as described below.

[0110]

When all of the front surfaces of the documents have been read in first, the storage capacity that is necessary for storing the number of documents and the image data for one surfaces of all the documents is clear. In addition, as described above, the read-out speed of image data in the rear-surface image data storage area 525 that is to be read

out concomitant with the printing by the image forming portion 300 and the storage speed of image data to be stored on the basis of the reading in of images by the image reading portion 200 can be determined beforehand.

[0111]

From the quantity of image data for the front surfaces of all the read-in documents (a total data quantity Q3 of the data quantity Q1 for the image I of Fig. 6, the data quantity (Q2 - Q1) for the image III, and the image quantity (Q3 - Q2) for the image V), it is therefore possible to obtain the quantity of image data for both sides of all the documents (a data quantity Q6 that is estimated as the total data quantity obtained by adding to the data quantity Q3 the same-quantity data quantity (Q6 - Q3)), to obtain the line segment 200a indicating the storage speed and the line segment 300a indicating the read-out speed that do not intersect, as shown in Fig. 11, in a similar manner to that shown in Fig. 10. With such a configuration, if it is possible to delay the timing at which printing starts until after the time T1 at which at least a data quantity (Q3a - Q3) has been stored in the rear-surface image data storage area 525, with respect to the time T0 at which the continuous reading in of the rear surfaces of all the documents starts, it is possible to delay the timing at which printing ends until after the time T2 at which the reading in ends, thus making it

possible to prevent the image data running out.

[0112]

Conversely to the description above, the storage capacity of the rear-surface image data storage area 525 could be set to a storage capacity that is less than the storage capacity that can hold image data for one surface of a document. In such a case, the start time of printing is similar to that shown in Fig. 10, but since the image data stored in the rear-surface image data storage area 525 in units of one document cannot be overwritten, as in this embodiment, it is necessary to manage the data by pointers. For example, if a pointer is set to the head of the storage area and image data has been stored in that storage area as far as the end thereof, the pointer is reset to the head again and the storage of image data continues. If the print speed is faster, the image data that has been stored in the vicinity of the storage area indicated by the pointer when that pointer is reset has already been used by the processing of the image forming portion 300, so there is no problem if it is overwritten and the data is deleted.

[0113]

In the embodiment described above, when printing is based on any desired document, an image based on the image data for the front surface of that document is formed onto paper first, followed by an image based on image data for the rear surface, but the setup could equally well be such

that the image based on image data for the rear surface is formed first, depending on the unique configuration of the machine in which the copy program is installed. In case of the copy machine 100, for example, if the sheets of paper that have been printed upon are not delivered into the paper delivery tray 320 but are delivered face-up by releasing the back cover (not shown in the figures), so that they are arranged in the sequence in which the documents are arranged. So, the print sequence of the image data for the front surfaces and the image data for the rear surfaces of the documents becomes opposite to that of this embodiment, as shown in Fig. 7.

[0114]

This print sequence instruction is handled as a variable of the recording request, but the timing of print start can be adjusted as shown in Fig. 12, in a similar way to that of Fig. 10. In other words, the reading of the image data for the rear surface starts at the time T0 and the timing of print start is delayed until after the time T1, to ensure that the timing at which the printing based on the image data for that rear surface ends is later than the time T3 at which the reading in of a quantity Q1 of the image data for the rear surface, which is estimated from the image data for the front surface, has been completed. In a similar manner, the time T1 is determined with reference to the time at which image data of a

predetermined data quantity Q0a has been stored in the rear-surface image data storage area 525, in such a manner that the line segment 200a indicating storage speed and the line segment 300a indicating read-out speed do not intersect. This makes it possible to prevent the image data from running out, even when the forming of an image based on the image data for the rear surface is done before the forming of an image based on the image data for the corresponding front surface.

[0115]

Note that the predetermined quantity of image data to be stored in the rear-surface image data storage area 525 could be set as a machine-specific setting beforehand as described with reference to Figs. 10 to 12, to act as a determination reference for measuring the timing of the start of printing in the image forming portion 300, but it is equally possible to determine the certain quantity of image data by creating a table or the like beforehand by experiments or the like, linking the certain quantity of image data to the quantity of image data for the front surfaces during the reading of the front surfaces of the documents, and by referring to the table during the processing.

[0116]

Furthermore, the copy machine 100 has been described as reading in images formed on both sides of a document

then printing those images on both sides of a sheet of paper by a double-sided print mechanism, in such a manner that the configuration thereof is copied exactly, but the present invention can also be applied to copying in which the configuration is changed from "double-sided" to "single-sided", with the images formed onto the front surfaces of two sheets of paper.

[Effects of the invention]

[0117]

As described above, the image copying device in accordance with the present invention as disclosed in claim 1 has a configuration in which images are read in one surface at a time from a plurality of documents that have images on both sides thereof. Since this device makes it possible to start the forming of images based on image data of documents that has been read in, before the reading of both surfaces of all the documents has been completed, it enables a shortening of the time required for copying all the documents.

[0118]

In addition to the effects of the invention as defined by claim 1, the image copying device of the present invention in accordance with claim 2 makes it possible to match the image data for one surface of an original document to the image data for the other surface thereof, making it possible to form images that are based thereon

onto one surface of a recording medium and another surface thereof, respectively, thus enabling the operator to obtain copies in the same state as the original documents.

[0119]

In addition to the effects of the invention as defined by claim 1 or 2, the image copying device of the present invention in accordance with claim 3 makes it possible to read in the other surfaces of documents in parallel with the forming of images based thereon onto recording medium, thus making it possible to start the image forming as appropriate while the other surfaces are being read, provided the reading of the first surfaces of all the documents has been completed, which enables efficient copying and also enables a shortening of the time required for copying all the documents.

[0120]

In addition to the effects of the invention as defined by any of claims 1 to 3, the image copying device of the present invention in accordance with claim 4 makes it possible to start the forming of images based on documents after the image data for at least one of the other surfaces of the documents has been stored, making it possible to prevent any shortage of image data for forming the images during the image forming, even when the speed at which documents are read in is slower than the speed at which images are created.

[0121]

In addition to the effects of the invention as defined by any of claims 1 to 3, the image copying device of the present invention in accordance with claim 5 makes it possible to prevent any shortage of image data for creating images during the creating of those images, by shifting the starting time for image creating in such a manner that the end time of image creating based on image data for all the documents is later than the end time of the reading in of the other surfaces of all the documents, taking all the documents as a unit.

[0122]

In addition to the effects of the invention as defined by any of claims 1 to 3, the image copying device of the present invention in accordance with claim 6 makes it possible to prevent any shortage of image data for forming images during the forming of those images, by shifting the starting time for image forming in such a manner that the end time of image forming based on image data for the other surface of a particular document is later than the end time of the reading in of the other surface of that document, when image forming based on image data for the other surface of that document is done before image forming of image data for the first surface.

[0123]

In addition to the effects of the invention as

defined by any of claims 1 to 3, the image copying device of the present invention in accordance with claim 7 makes it possible to prevent any shortage of image data for forming images during the forming of those images, by shifting the starting time for image forming in such a manner that the end time of image forming based on image data for the both surfaces of a particular document is later than the end time of the reading in of the other surface of that document, when image forming based on image data for one surface of that document is performed before image forming based on image data for the other surface.

[0124]

In addition to the effects of the invention as defined by any of claims 1 to 7, the image copying device of the present invention in accordance with claim 8 makes it possible to prevent image forming based on null data, by control such as to temporarily halt the operation of the image forming means during the forming of an image if image data for forming that image is insufficient, even when the speed at which documents are read in is slower than the speed at which images are formed.

[0125]

In addition to the effects of the invention as defined by any of claims 1 to 7, the image copying device of the present invention in accordance with claim 9 makes it possible to temporarily halt the reading in of documents

to synchronize the processes for each document, by completing the forming of an image based on image data for the other surface of a read-in document before reading in the image of the other surface of the next document, even when the speed at which documents are read in is slower than the speed at which images are formed.

[0126]

In addition to the effects of the invention as defined by any of claims 1 to 9, the image copying device of the present invention in accordance with claim 10 ensures that the image data for the one surfaces of the documents that are stored in the storage means is read out alternately with the image data for the other surfaces thereof, and also that, during the forming of images based thereon, the image data for the one surface of each page is read out after image data for pages that was read in after the subject page was read in is read out, making it possible for the operator to avoid the work of reconfiguring the document arrangement sequence and the copied recording media sequence, when the other surfaces are read in after the one surfaces have been read.

[0127]

Note that the document arrangement sequence means the forward sequence in which the documents have been arranged for reading in, or it could mean the reverse sequence, or it could mean any arbitrary sequence. If page numbers are

exhibited on the documents, by way of example, the documents placed on the paper supply tray could be stacked in ascending order of page number, or they could be stacked in descending order of page number. Or they could be stacked in any sequence.

[0128]

In addition to the effects of the invention as defined by any of claims 1 to 10, the image copying device of the present invention in accordance with claim 11 makes it possible to delete image data for which image forming has ended so that the next image data can be stored in the thus-emptied storage area, enabling more efficient usage of the storage area.

[0129]

In addition to the effects of the invention as defined by any of claims 1 to 11, the image copying device of the present invention in accordance with claim 12 makes it possible to use the second storage area more efficiently and also reduce the capacity thereof, by overwriting image data for which image forming has ended, when the image data for the other surface of the document is stored in the second storage area.

[0130]

In addition to the effects of the invention as defined by claim 12, the image copying device of the present invention in accordance with claim 13 makes it

possible to provide the second storage area with a capacity for storing only one page of image data, enabling efficient use of the second storage area, by overwriting image data for which image forming has ended, in units of one document page.

[0131]

In addition to the effects of the invention as defined by claim 12 or 13, the image copying device of the present invention in accordance with claim 14 makes it possible to simplify the management of the storage locations for image data within the storage areas, by ensuring that the image data for one side of the document and the image data for the other side of the document are not stored to extend into the other storage area.

[0132]

In addition to the effects of the invention as defined by any of claims 12 to 14, the image copying device of the present invention in accordance with claim 15 makes it possible to increase the storage capacity of the first storage area and increase the number of documents that can be handled at the same time, by setting the second storage area to have a storage capacity smaller than that of the first storage area.

[0133]

In addition to the effects of the invention as defined by any of claims 12 to 15, the image copying device

of the present invention in accordance with claim 16 makes it possible to prevent any inconvenience caused by a halt in the copying due to insufficient storage capacity even when a copy instruction has been received, by starting the reading in of documents after the minimum necessary spare capacity is reserved, by checking the storage capacity of each of the first storage area and the second storage area.

[0134]

In addition to the effects of the invention as defined by claim 16, the image copying device of the present invention in accordance with claim 17 ensures that there is no shortage of storage capacity at the storage destination of image data, during the reading in of one document, by ensuring that the spare capacity in each of the first storage area and the second storage area is greater than the capacity of image data based on at least one document.

[0135]

In addition to the effects of the invention as defined by any of claims 12 to 17, the image copying device of the present invention in accordance with claim 18 makes it possible to increase number of documents that can be handled at the same time, by enabling compression of the image data before storage.

[0136]

In addition to the effects of the invention as

defined by any of claims 1 to 18, the image copying device of the present invention in accordance with claim 19 makes it possible to form images on both sides of the recording medium, reducing the work of the operator during the copying of documents that have images formed on both surfaces thereof.

[Brief Description of the Drawings]

[Fig. 1]

A perspective view of a copy machine 100

[Fig. 2]

A cross-section of an essential part of an image reading portion 200 taken along the broken line A-A' in Fig. 1

[Fig. 3]

A cross-section of an essential part of an image forming portion 300 taken along the broken line B-B' in Fig. 1

[Fig. 4]

A block diagram of an electrical configuration of the copy machine 100

[Fig. 5]

A conceptual diagram of storage areas allocated in a RAM 520

[Fig. 6]

A schematic view of the relationship between the stacking direction of the documents in the image reading

portion 200, together with the vertical direction of images formed on the documents, and the storage directions within the storage areas for the image data of the read-in documents

[Fig. 7]

A schematic view of the relationship between the direction in which image data that has been stored in the storage area for the image data is read out during printing by the image forming portion 300 and the vertical direction of images formed on the paper, together with the stacking direction of paper in the discharge tray

[Fig. 8]

A flowchart of the copy program for implementing double-sided copying

[Fig. 9]

A flowchart of the copy program for implementing double-sided copying

[Fig. 10]

A graph indicating the relationship between the speed at which image data is read out based on the printing of the image forming portion 300 and the speed at which image data is stored based on the reading in of data by the image reading portion 200

[Fig. 11]

A graph indicating the relationship between the speed at which image data is read out based on the printing of

the image forming portion 300 and the speed at which image data is stored based on the reading in of data by the image reading portion 200

[Fig. 12]

A graph indicating the relationship between the speed at which image data is read out based on the printing of the image forming portion 300 and the speed at which image data is stored based on the reading in of data by the image reading portion 200

[Description of Reference Numerals]

100 copy machine

200 image reading portion

300 image forming portion

520 RAM

524 front-surface image data storage area

525 rear-surface image data storage area

560 compression/decompression portion

[Name of the Document] Abstract

[Abstract]

[Problem] A copy machine is provided that can read in the other surfaces of the plurality of documents after reading in the front surfaces of the first documents is completed, and start forming images before reading in the other surfaces of the all the documents is completed.

[Means for Solving] A copy machine reads in the front surfaces of a plurality of documents, then starts to read in of the rear surfaces of the documents. It takes a period of time from a time T2 to a time T7 to read in image data of a quantity (Q2 - Q1) from the rear surface of one document as apparent from a line segment 200a that is indicative of the speed at which the read-in image data is stored. This quantity (Q2 - Q1) of the image data from the rear surface is estimated to be equal to the quantity Q1 of the image data from the front surface. The time required for printing the double-sided data quantity Q2 is from a T0 to a time T6 on a line segment 300a indicating read-out speed, and the timing of printing start is delayed to a time T1 to ensure that the line segment 200a and the line segment 300a do not intersect, which prevent the image data from being depleted based on the difference between the speed of storing and the speed of reading in. This makes it possible to start the printing based on image data for the rear surface of a document, during the reading of that

surface.

[Selected Figure] Fig. 10

[Title of Document] Drawings

FIG.1

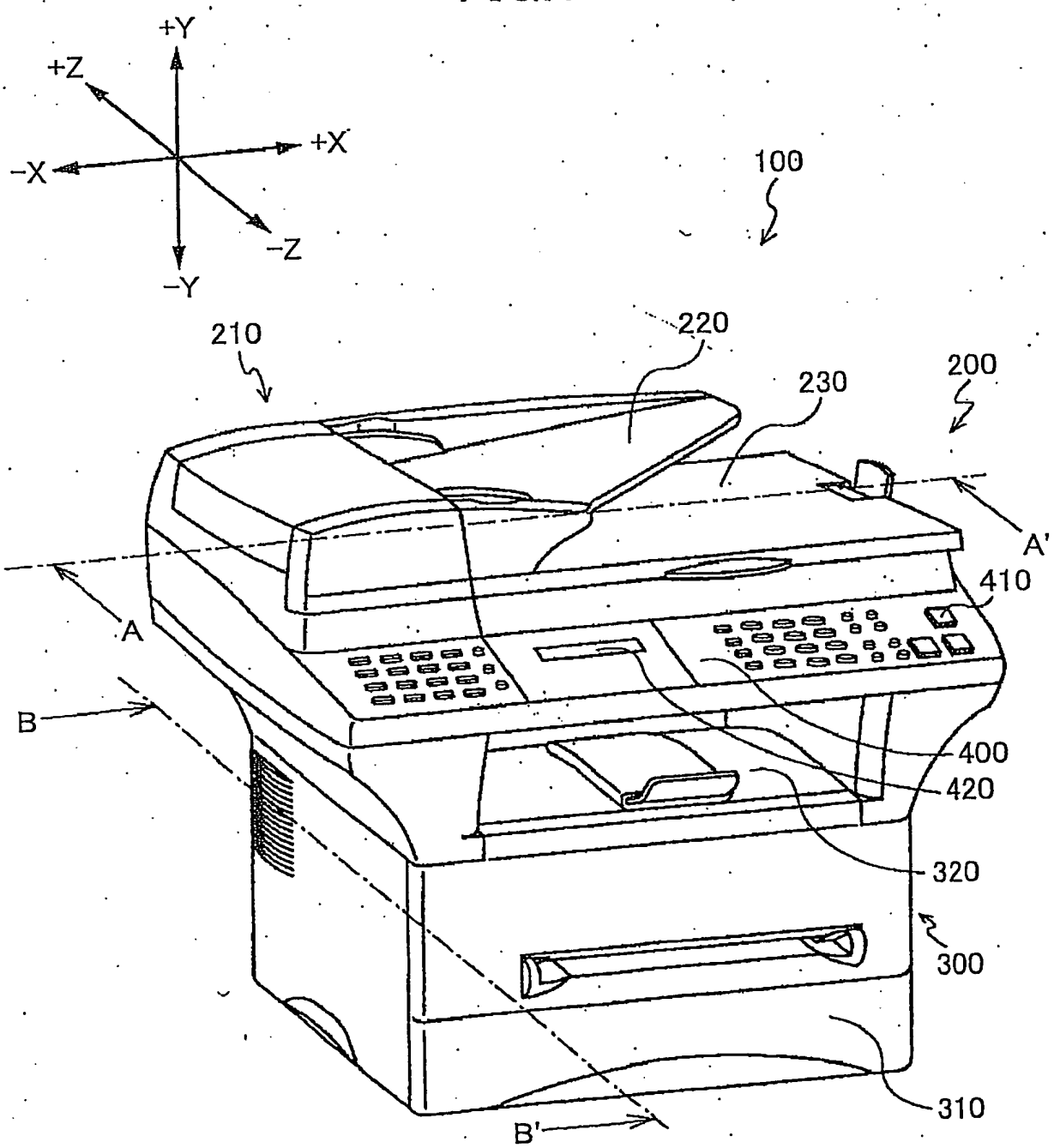

FIG.2

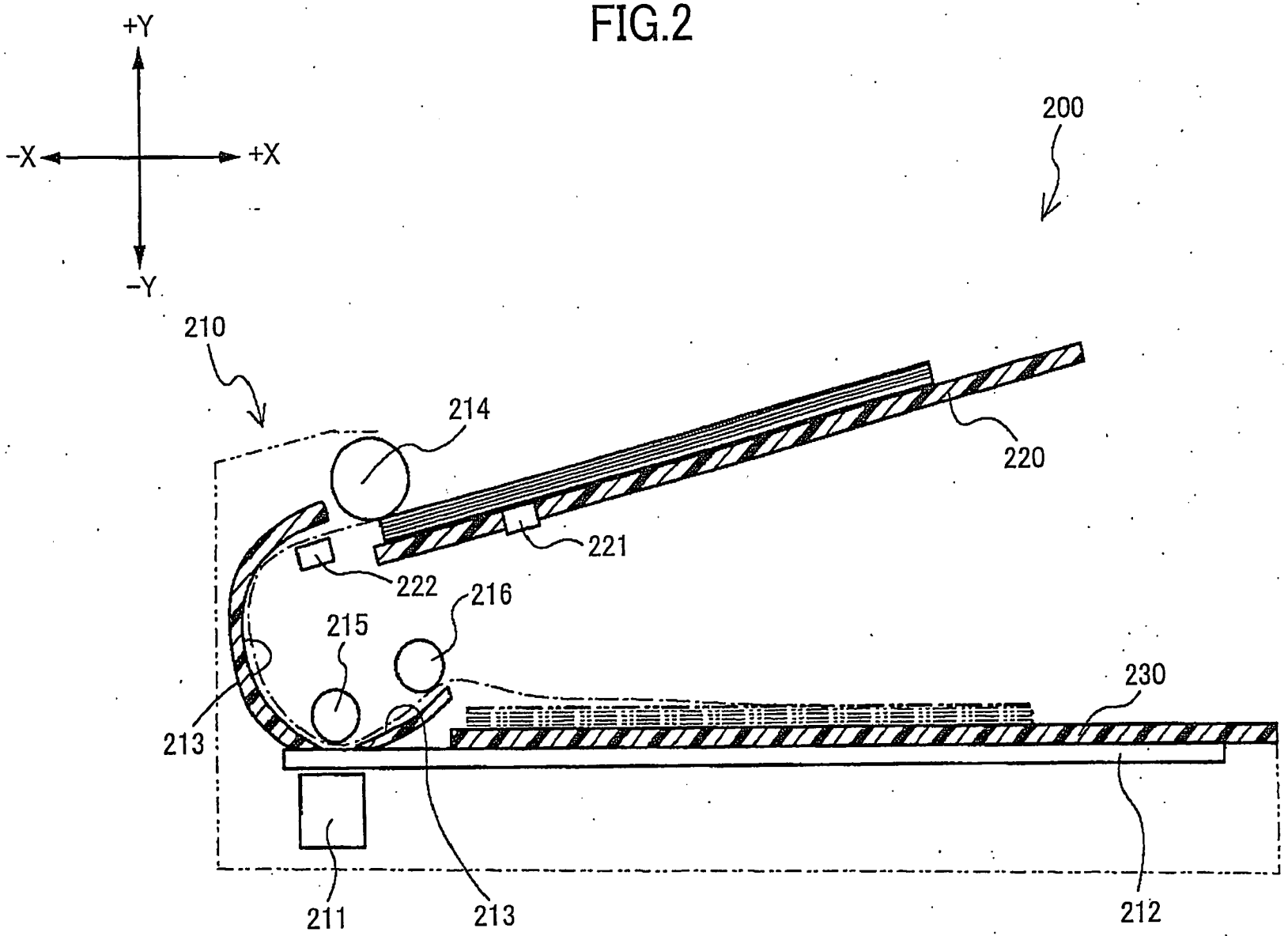

FIG.3

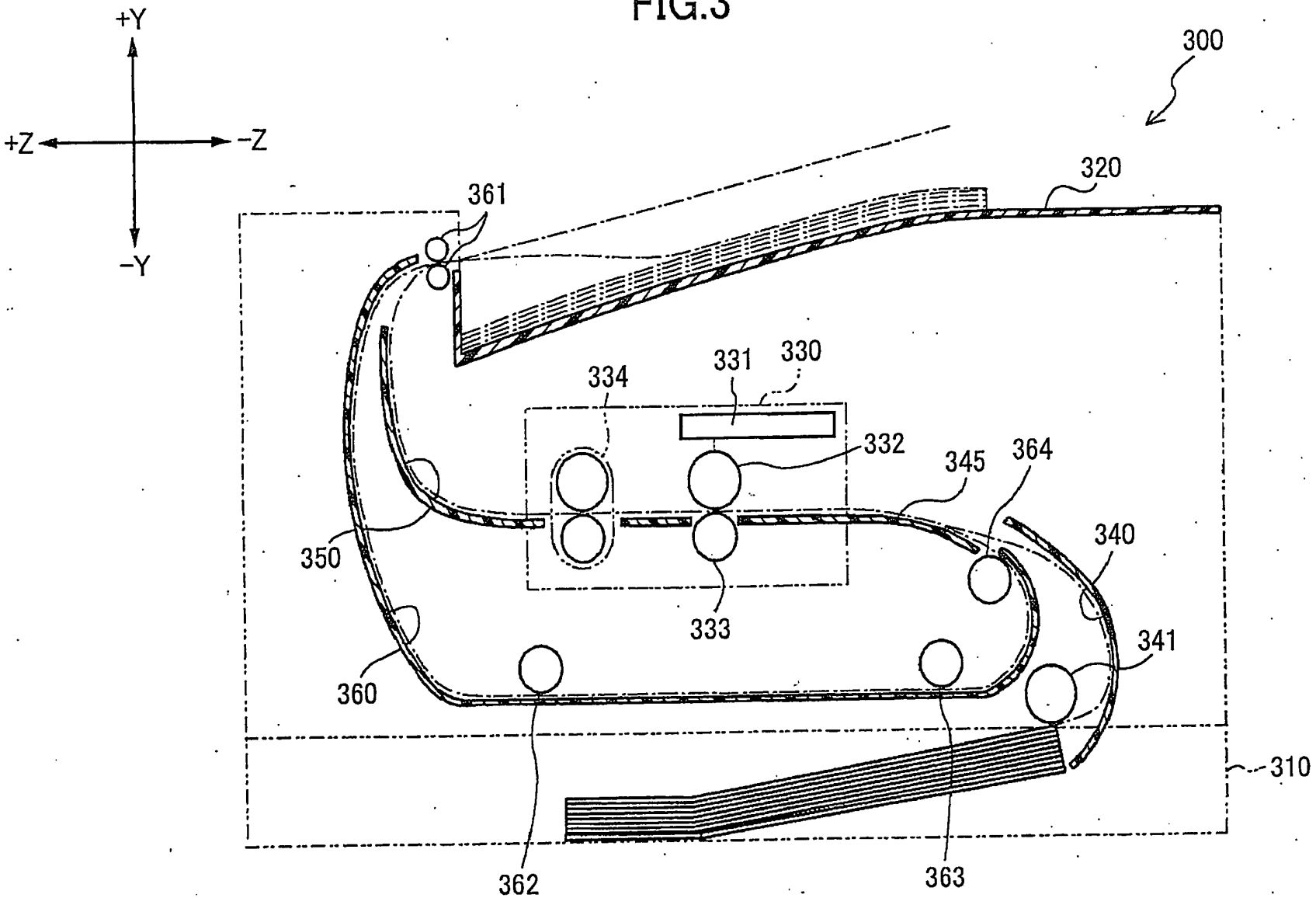
+Y
-Y
+Z
-Z
300
320
361
331
330
334
332
345
364
340
350
333
341
360
310
362
363

FIG.4

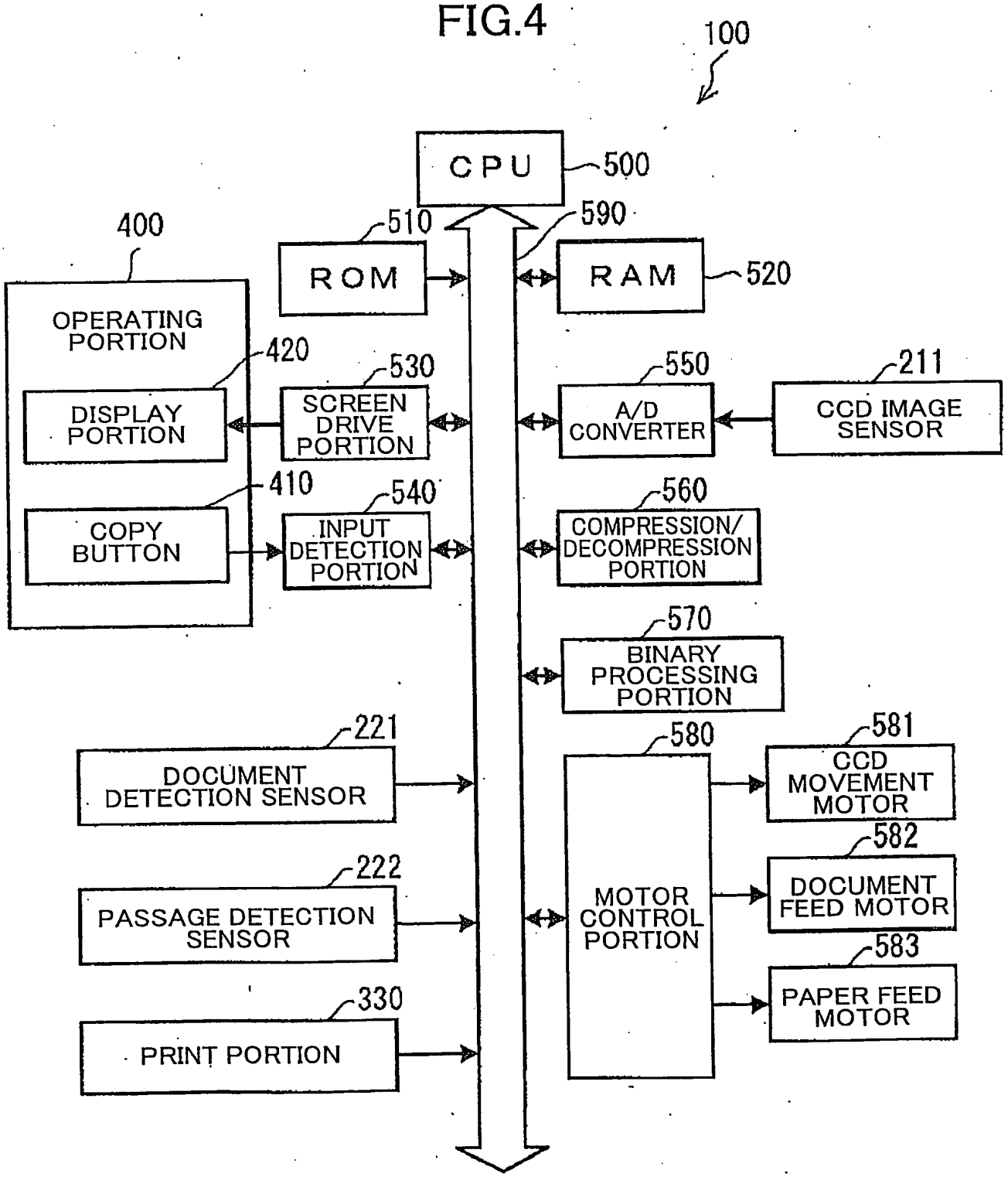
100
CPU
500
510
ROM
590
RAM
520
400
OPERATING PORTION
420
DISPLAY PORTION
530
SCREEN DRIVE PORTION
410
COPY BUTTON
540
INPUT DETECTION PORTION
550
A/D CONVERTER
211
CCD IMAGE SENSOR
560
COMPRESSION/ DECOMPRESSION PORTION
570
BINARY PROCESSING PORTION
221
DOCUMENT DETECTION SENSOR
222
PASSAGE DETECTION SENSOR
330
PRINT PORTION
580
MOTOR CONTROL PORTION
581
CCD MOVEMENT MOTOR
582
DOCUMENT FEED MOTOR
583
PAPER FEED MOTOR

FIG.5

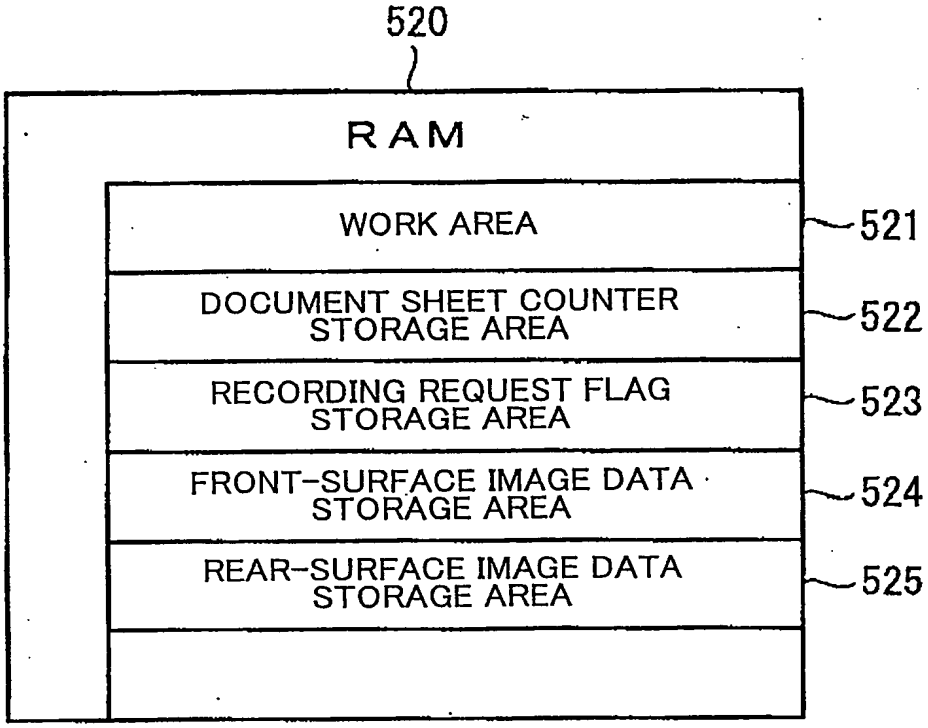
520
RAM
WORK AREA
521
DOCUMENT SHEET COUNTER STORAGE AREA
522
RECORDING REQUEST FLAG STORAGE AREA
523
FRONT-SURFACE IMAGE DATA STORAGE AREA
524
REAR-SURFACE IMAGE DATA STORAGE AREA
525

FIG.6

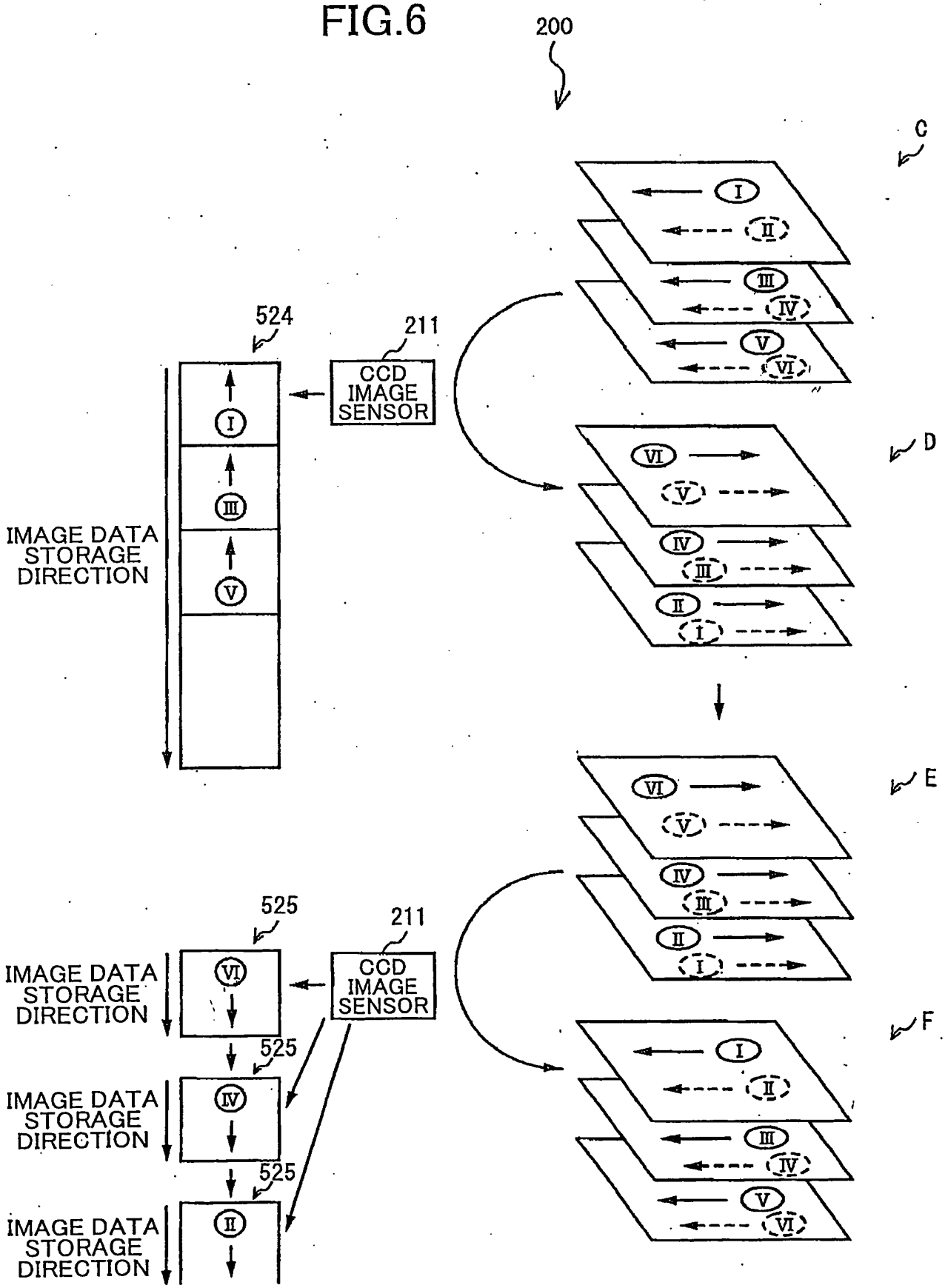
200
C
D
E
F
524
211
CCD IMAGE SENSOR
IMAGE DATA STORAGE DIRECTION
525
211
CCD IMAGE SENSOR
IMAGE DATA STORAGE DIRECTION
525
IMAGE DATA STORAGE DIRECTION
525
IMAGE DATA STORAGE DIRECTION

FIG.7

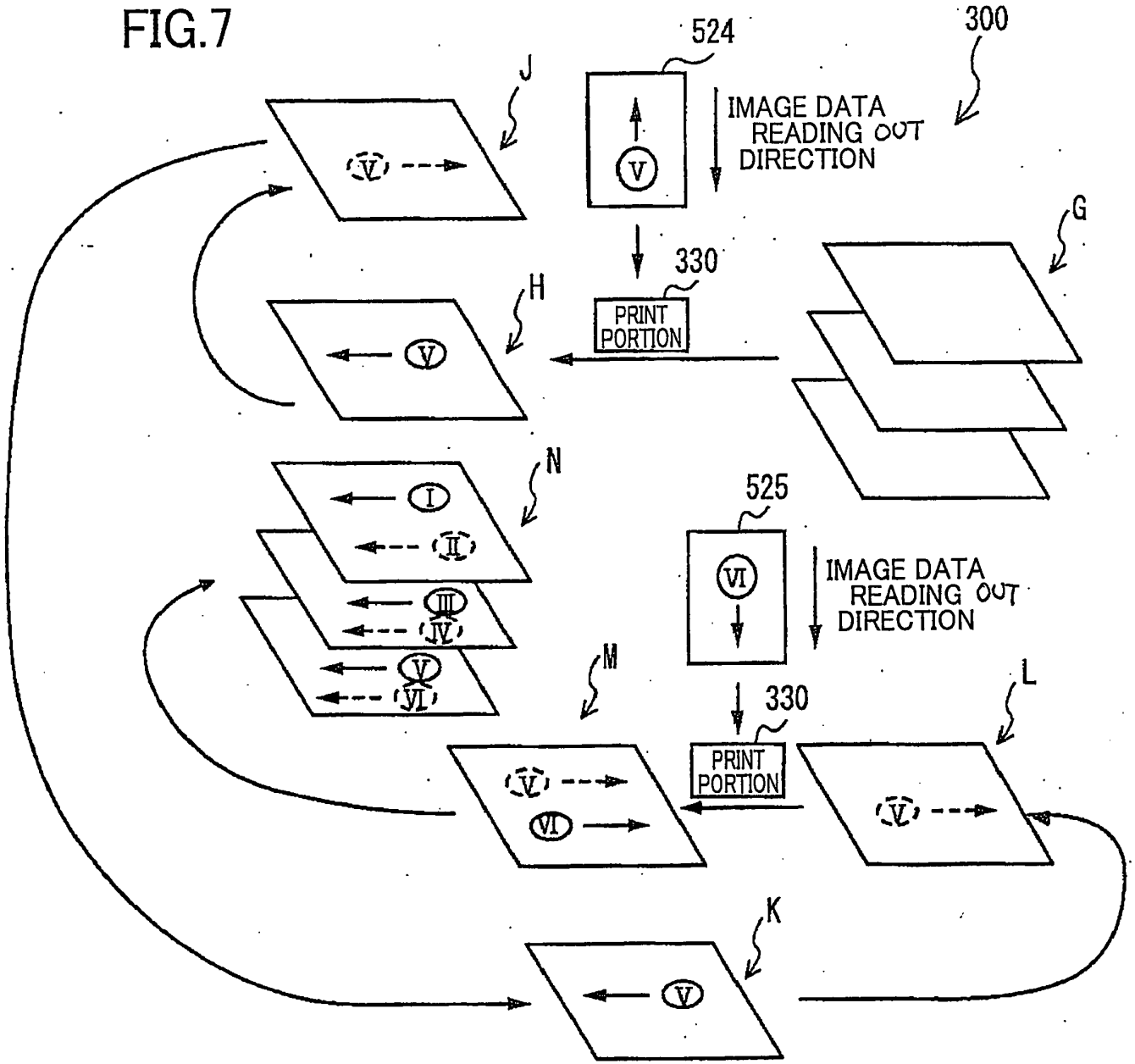
524
300
J
IMAGE DATA READING OUT DIRECTION
G
330
H
PRINT PORTION
N
525
IMAGE DATA READING OUT DIRECTION
M
330
L
PRINT PORTION
K

FIG.8

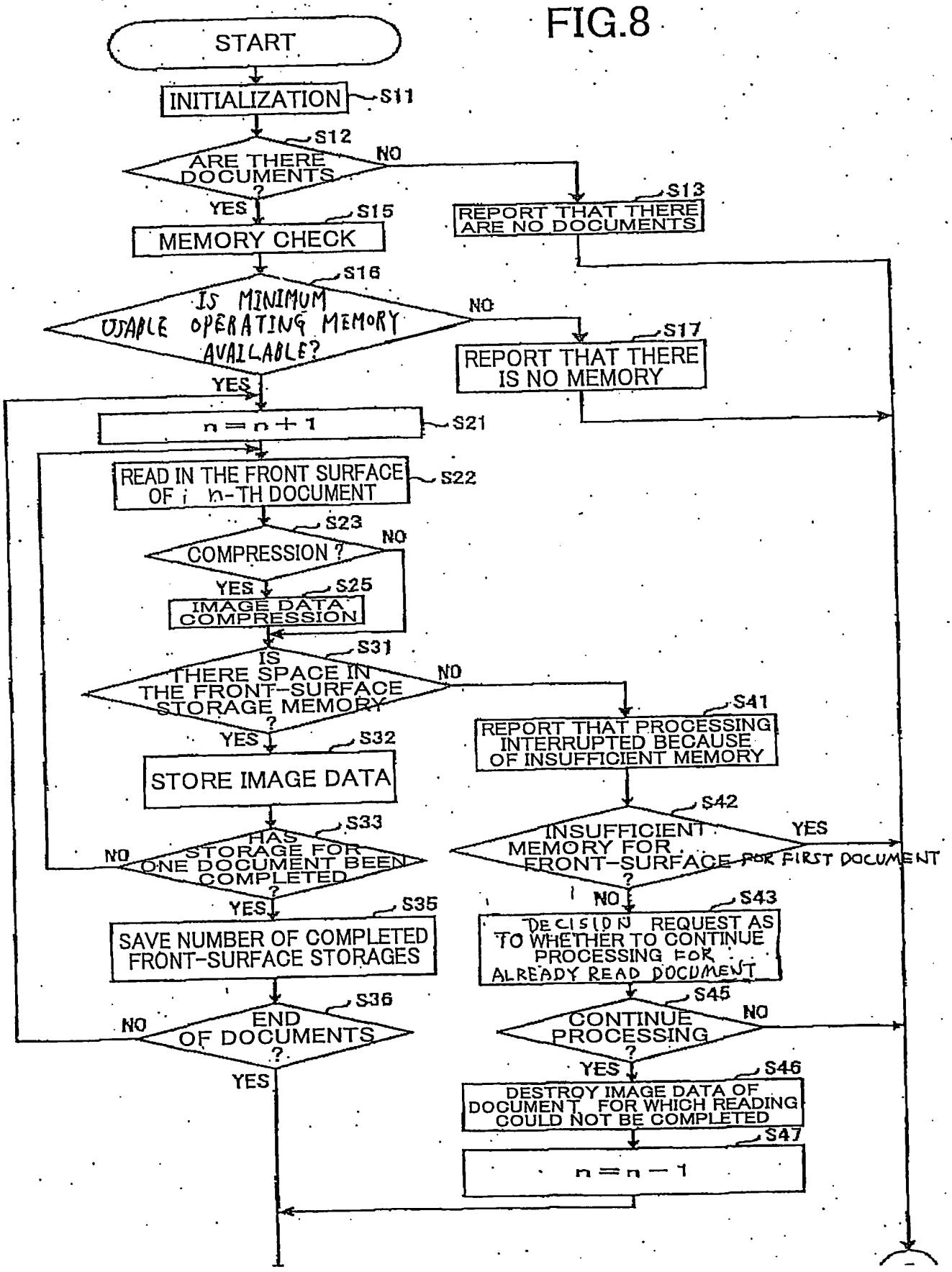
START
INITIALIZATION
S11
S12
ARE THERE DOCUMENTS ?
NO
YES
S13
REPORT THAT THERE ARE NO DOCUMENTS
S15
MEMORY CHECK
S16
IS MINIMUM USABLE OPERATING MEMORY AVAILABLE?
NO
S17
REPORT THAT THERE IS NO MEMORY
YES
n = n + 1
S21
READ IN THE FRONT SURFACE OF i n-TH DOCUMENT
S22
S23
COMPRESSION ?
NO
YES
S25
IMAGE DATA COMPRESSION
S31
IS THERE SPACE IN THE FRONT-SURFACE STORAGE MEMORY ?
NO
YES
S32
STORE IMAGE DATA
S33
HAS STORAGE FOR ONE DOCUMENT BEEN COMPLETED ?
NO
YES
S35
SAVE NUMBER OF COMPLETED FRONT-SURFACE STORAGES
S36
END OF DOCUMENTS ?
NO
YES
S41
REPORT THAT PROCESSING INTERRUPTED BECAUSE OF INSUFFICIENT MEMORY
S42
INSUFFICIENT MEMORY FOR FRONT-SURFACE ?
YES
FOR FIRST DOCUMENT
NO
S43
DECISION REQUEST AS TO WHETHER TO CONTINUE PROCESSING FOR ALREADY READ DOCUMENT
S45
CONTINUE PROCESSING ?
NO
YES
S46
DESTROY IMAGE DATA OF DOCUMENT FOR WHICH READING COULD NOT BE COMPLETED
S47
n = n − 1

FIG.9

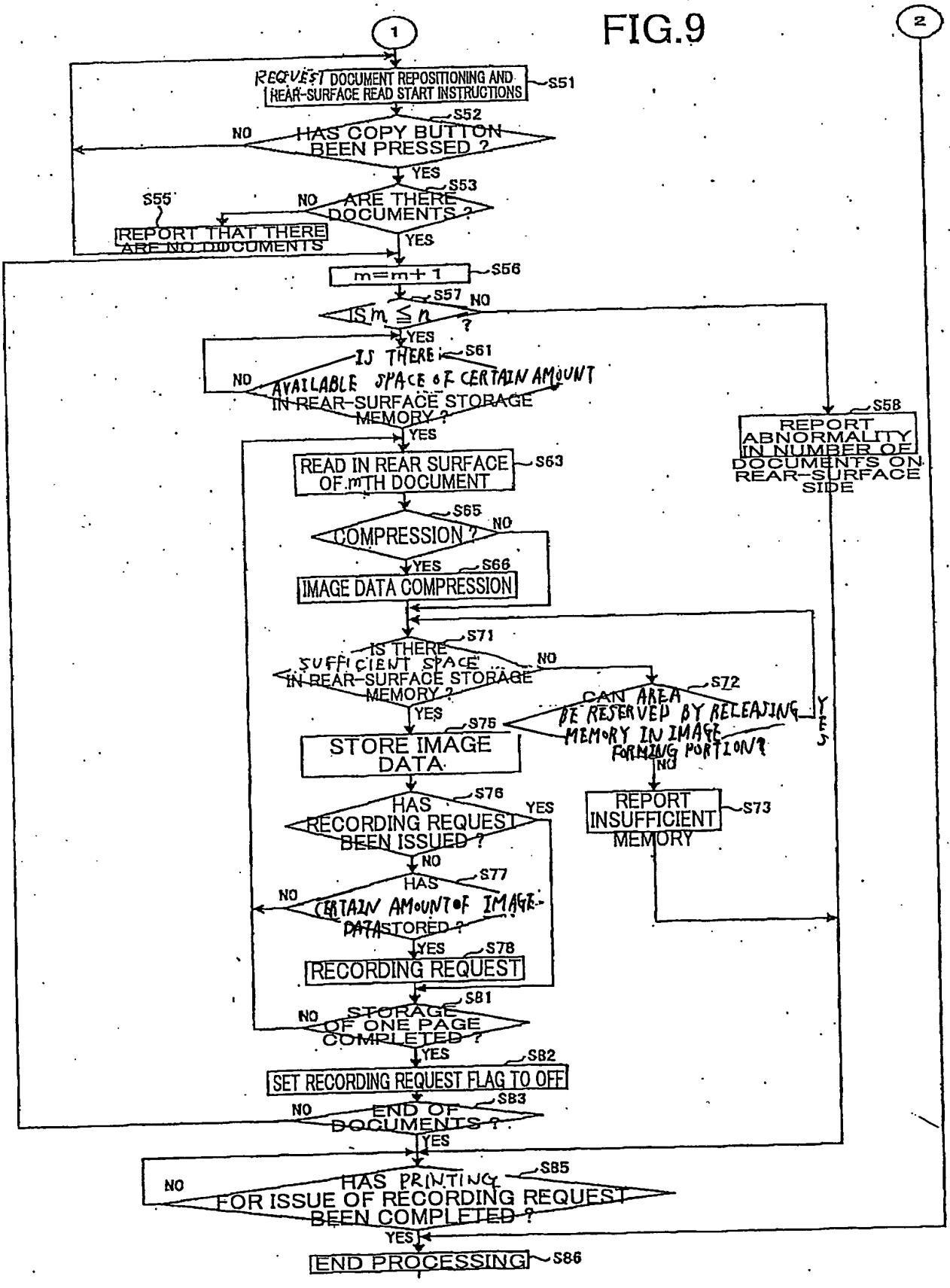
1
2
REQUEST DOCUMENT REPOSITIONING AND REAR-SURFACE READ START INSTRUCTIONS
S51
S52
HAS COPY BUTTON BEEN PRESSED ?
NO
YES
S53
ARE THERE DOCUMENTS ?
NO
S55
REPORT THAT THERE ARE NO DOCUMENTS
YES
m=m+1
S56
S57
IS m ≦ n ?
NO
YES
S58
REPORT ABNORMALITY IN NUMBER OF DOCUMENTS ON REAR-SURFACE SIDE
S61
IS THERE AVAILABLE SPACE OF CERTAIN AMOUNT IN REAR-SURFACE STORAGE MEMORY ?
NO
YES
READ IN REAR SURFACE OF mTH DOCUMENT
S63
S65
COMPRESSION ?
NO
YES
S66
IMAGE DATA COMPRESSION
S71
IS THERE SUFFICIENT SPACE IN REAR-SURFACE STORAGE MEMORY ?
NO
YES
S72
CAN AREA BE RESERVED BY RELEASING MEMORY IN IMAGE FORMING PORTION ?
YES
NO
S75
STORE IMAGE DATA
REPORT INSUFFICIENT MEMORY
S73
S76
HAS RECORDING REQUEST BEEN ISSUED ?
YES
NO
S77
HAS CERTAIN AMOUNT OF IMAGE DATA STORED ?
NO
YES
S78
RECORDING REQUEST
S81
STORAGE OF ONE PAGE COMPLETED ?
NO
YES
S82
SET RECORDING REQUEST FLAG TO OFF
S83
END OF DOCUMENTS ?
NO
YES
S85
HAS PRINTING FOR ISSUE OF RECORDING REQUEST BEEN COMPLETED ?
NO
YES
END PROCESSING
S86

FIG.10

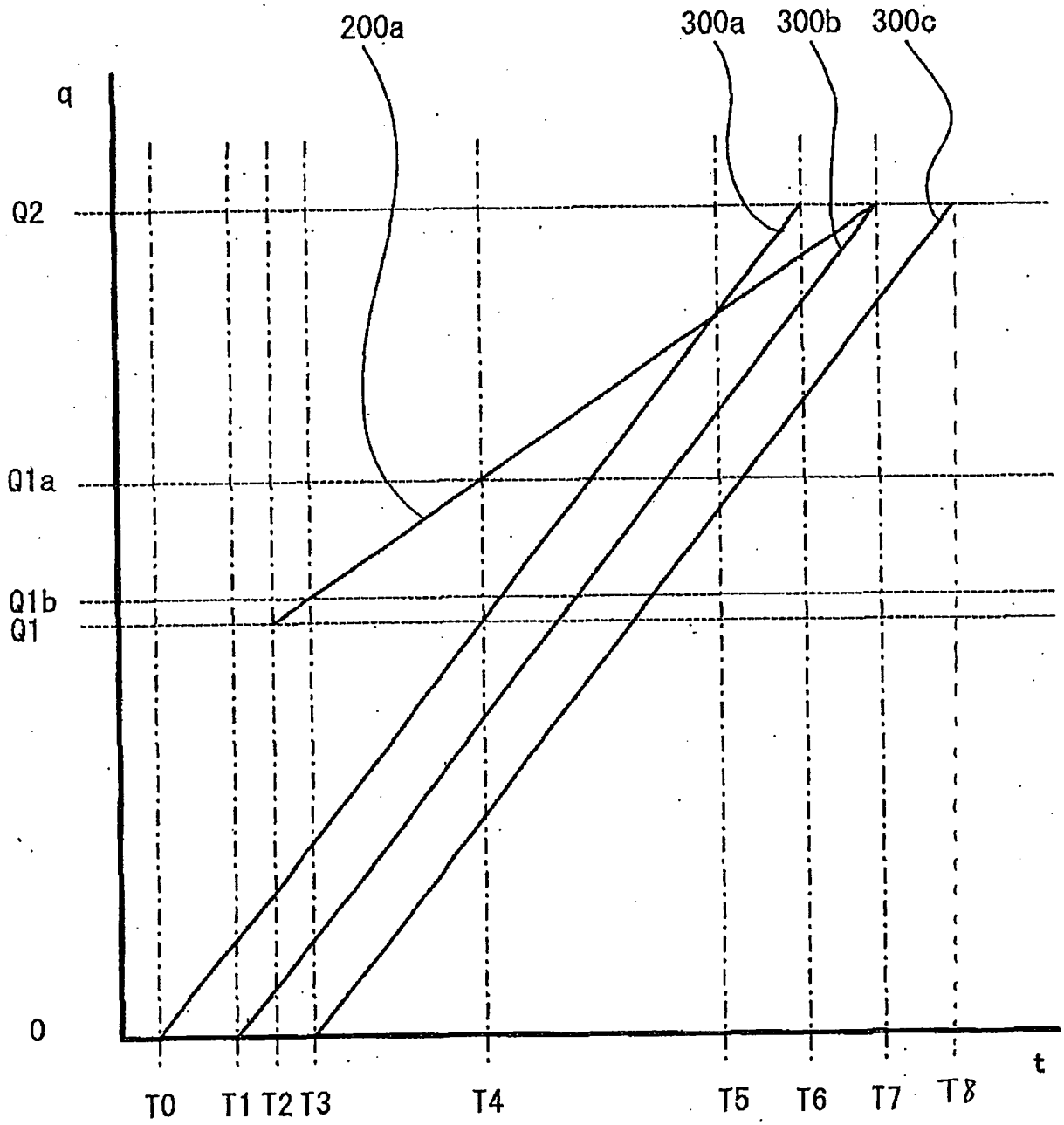

FIG.11

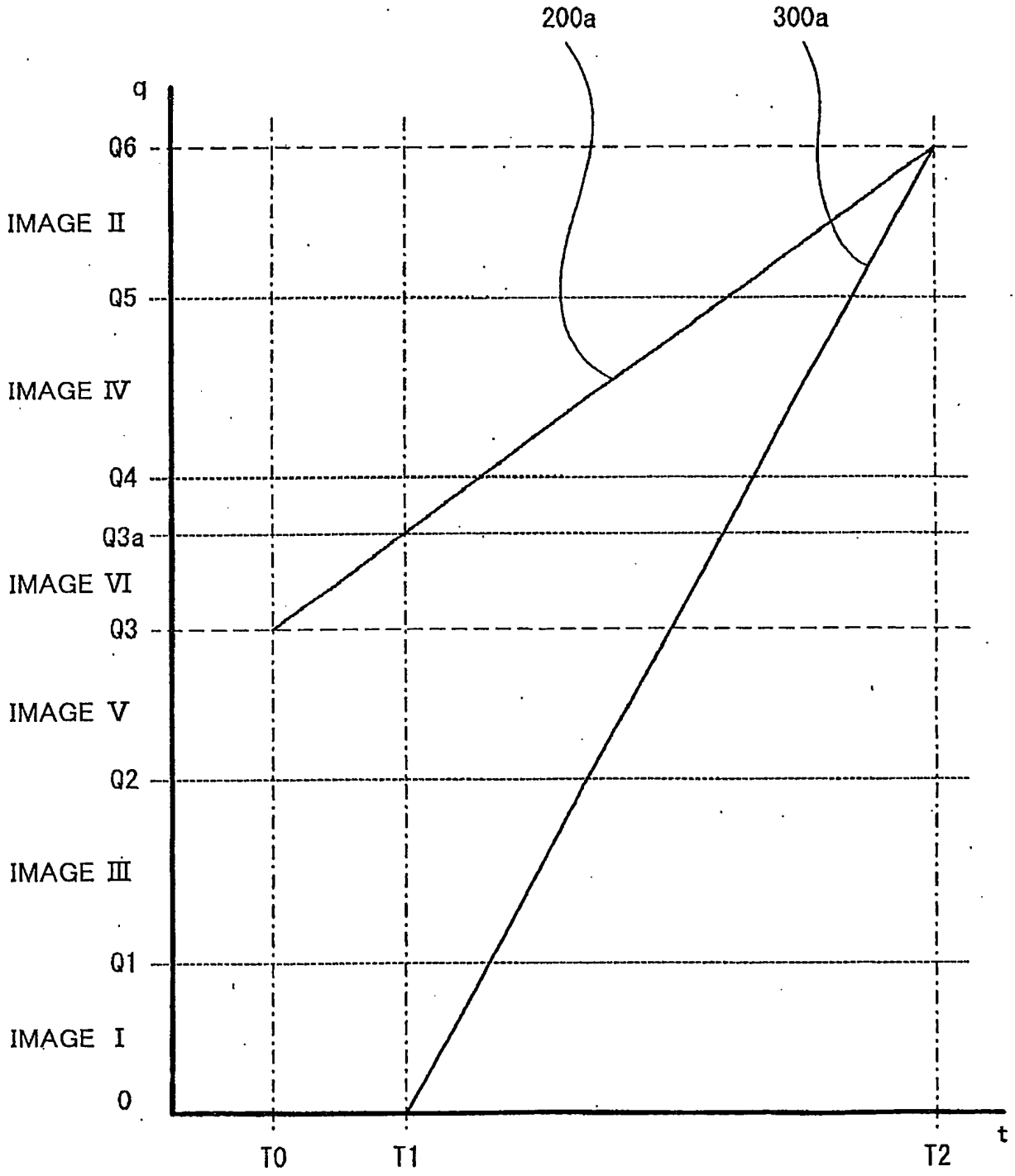
200a
300a
q
Q6
IMAGE II
Q5
IMAGE IV
Q4
Q3a
IMAGE VI
Q3
IMAGE V
Q2
IMAGE III
Q1
IMAGE I
0
T0
T1
T2
t

FIG.12